

NAC flight unit 1 calibration summary log
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7/29/08

Formats for the calibration data:

The .ddd images are 8-bit raw format from the GSE, with an image of even columns first and an image of odd columns second. The images were taken in mode 0, mode 10, and mode 30.

Mode 0 images use companding tables lin1 (straight DN except it rolls over to 0 at 256, 512, etc), lin16 (image is DN/16 and saturates at DN/16=255), and sqroot. The sqroot companding table takes the 12-bit DN and converts it to 8 bits using the first table given in the last worksheet ("compand") of this workbook. Each .ddd mode 0 image has twice as many lines as it should with the even columns first and the odd columns second. Interleaved images have filenames like N12gQa0i.ddd, and are post processed to have the even and odd columns properly Mixed. FITS images have filenames like N12gQa0i.fit, and are interleaved in FITS standard astronomical format. In mode 0, the hardware subtracts the A offset value from the (zero based counting) even columns and the B offset value from the odd columns.

Mode 10 .ddd images are even more complex. The even columns (zero based counting) are saved in full 12-bit form, with values 0-4095. The odd columns are saved in 4-bit form, with values 0-15. The 12 bit and 4 bit values are packed into two 8-bit words in the raw .ddd image. Mode 30 is the same as mode 10 except the 12-bit data is kept for the the odd columns and 4-bit for the even columns. In the lab, a mode 30 image was taken for each mode 10 image, so the full 12 bits would be available for all columns. The raw .ddd files are difficult to interpret and I recommend using only the FITS files for analysis of mode 10 and mode 30 images. Each FITS file is made from one mode 10 raw image and one mode 30 raw image. The name of the FITS file is derived from the mode 10 image. For example, FITS image N20cSd0.i12.fit is derived from mode 10 image N20cSd0.ddd and mode 30 image N20cSe0.ddd. In mode 10 and mode 30, the companding table and the A and B offset values are not used.

All of the images described in this workbook have 128 lines, with 896 lines of preroll for the GSE. In theory, the GSE is capable of taking images with more lines, but we took a number of bad images with more than 128 lines and we were not successful in taking good ones.

Raw NAC calibration file naming convention is <http://roc.sese.asu.edu/WORK/CALB/NAC1/SD/LROC-namingconvention.doc>

NAC 1 Calibration Tests

Geometric calibration

Detector characterization test with QTH and Spectralon panel

Detector characterization test with dark source

Detector characterization test with photo lamps

Flat field with mode 0, lin16 companding table only

Detector characterization test with QTH and Spectralon panel at multiple DAC levels

Leaked light with white LED flashlight shining into various spots

Stray light with QTH shining directly into NAC telescope aperture

Responsivity as a function of wavelength up to a constant

Flat field with mode 10 and mode 30

Flat field with mode 10 and mode 30 taken two months later, after NAC2 calibration

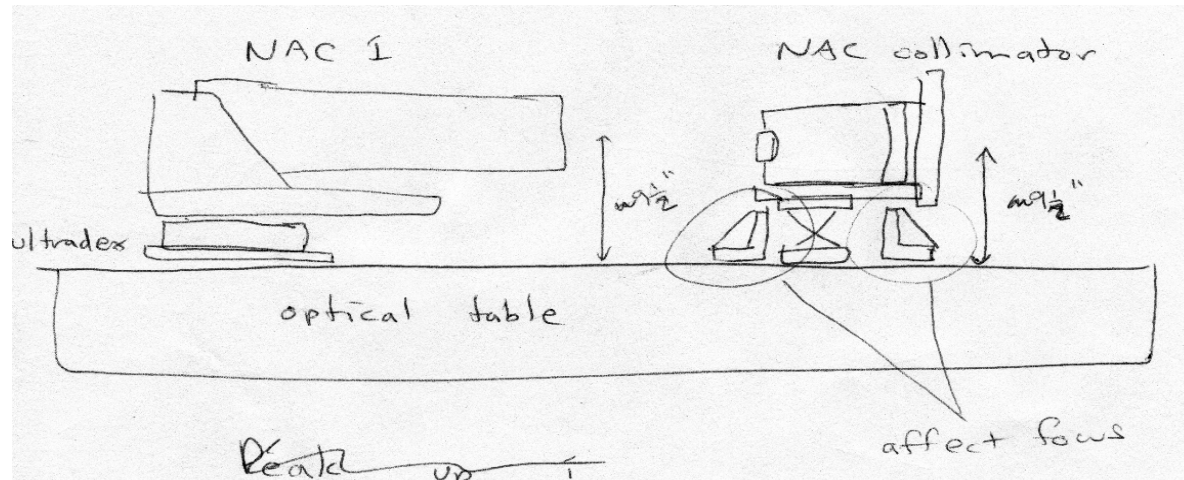
Flat field with source of ghost obscured by black plate

Detector characterization test with dark source taken two months after the first one, after NAC2 calibration

Stray light with sphere with 1 inch aperture and Xe lamp

Detector characterization test with QTH and sphere with 4 inch aperture

NACFU1 geometric calibration



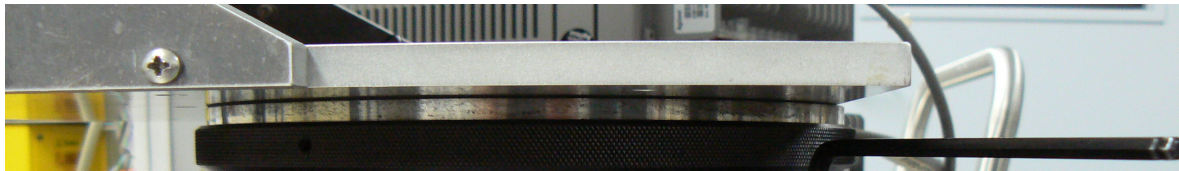
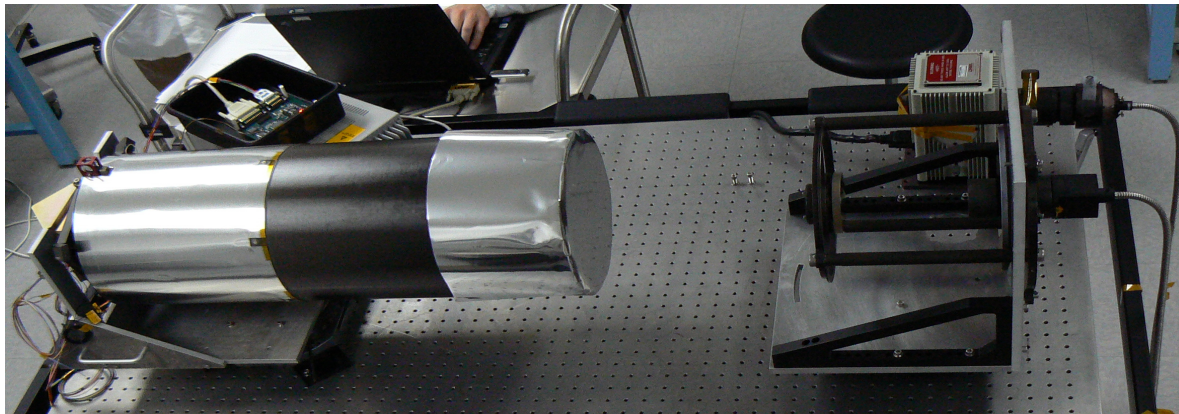
Data were taken 2/6/2008.

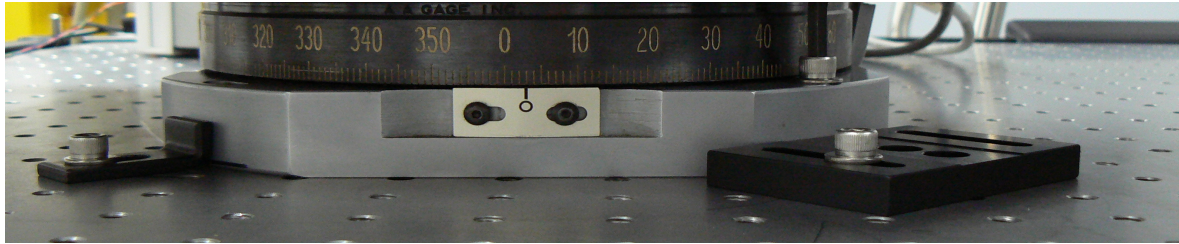
The NACFU1 instrument was set up on the Ultradex rotation stage looking at the NAC collimator.

The NAC collimator had a bar target approximately at its focus, but tilted with respect to its focal plane so one bar is in best focus and the rest are more or less out of focus.

The bars are alternately clear and opaque black, and they are illuminated from behind.

The angle of tilt with respect to the focal plane is 2.4 degrees.





The Ultradex stage allows extremely accurate calibrated rotations of 1 inch each. That's a bit too coarse for geometric calibration of the 2.8 degree NAC field of view. We performed 20 unmeasured rotations of the base of the stage. The axis of the unmeasured rotations was fixed by plates bolted to the optical table. For each unmeasured rotation position, the base of the Ultradex stage was bolted down and we took an image at each of several rotation positions separated by exactly 1 degree, achieved by rotating the Ultradex stage.

Calibration parameters				NAC parameters							
Filename	Ultradex angle (Unconstrained r Potentially usefi Dark			Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N12gQa0.ddd	A	No		Taken for setup	0	Lin16	199	0	40	300	2.895
N12gQa1.ddd	B	No		Taken for setup	0	Lin16	199	0	40	300	2.895
N12gQa2.ddd	C	No		Taken for setup	0	Lin16	199	0	40	300	2.895
N12gQa3.ddd	356 D	Yes			0	Lin16	199	0	40	300	2.895
N12gQa4.ddd	355 D	Yes			0	Lin16	199	0	40	300	2.895
N12gQa5.ddd	357 D	Yes			0	Lin16	199	0	40	300	2.895
N12gQa6.ddd	356 D	Yes			0	Lin16	199	0	40	300	2.895
N12dQa0.ddd		No	Shuttered		0	Lin16	199	0	40	300	2.895
N12gQb0.ddd	356 E	Yes			0	Lin16	199	0	40	300	2.895
N12gQb1.ddd	354 E	Yes		Previous images may have mori	0	Lin16	199	0	40	300	2.895
N12gQb2.ddd	357 E	Yes			0	Lin16	199	0	40	300	2.895
N12gQb3.ddd	357	1 Yes			0	Lin16	199	0	40	300	2.895
N12gQc0.ddd	357	1 Yes			0	Lin16	199	0	40	300	2.895
N12gQc1.ddd	356	1 Yes			0	Lin16	199	0	40	300	2.895
N12gQc2.ddd	355	1 Yes			0	Lin16	199	0	40	300	2.895
N12gQc3.ddd	355	2 Yes			0	Lin16	199	0	40	300	2.895

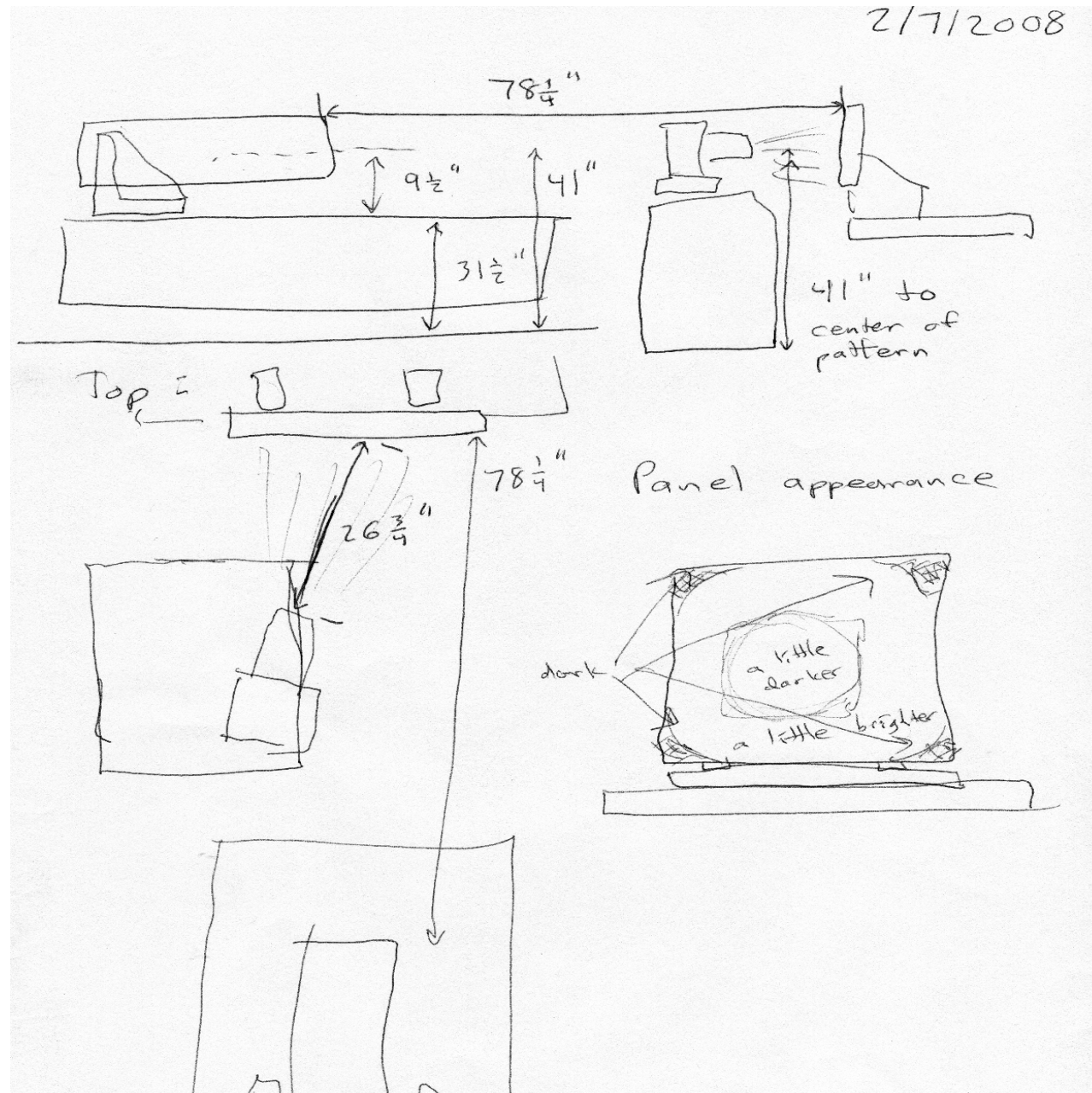
...insert additional filenames and data, starting with page 4 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080206to8-CalLog.pdf>

N12gQd10.ddd	354	20 No			0	Lin1		199	0	40	300	2.895
N12dQb0.ddd		No	Shuttered		0	Lin1		199	0	40	300	2.895
N12dQb1.ddd		No	Shuttered		0	Lin16		199	0	40	300	2.895
N12dQb2.ddd		No	Shuttered, lamp off		0	Lin16		199	0	40	300	2.895
N12dQb3.ddd		No	Shuttered, lamp off		0	Lin16		199	0	40	300	2.895

Analysis available as of 6/25/2008

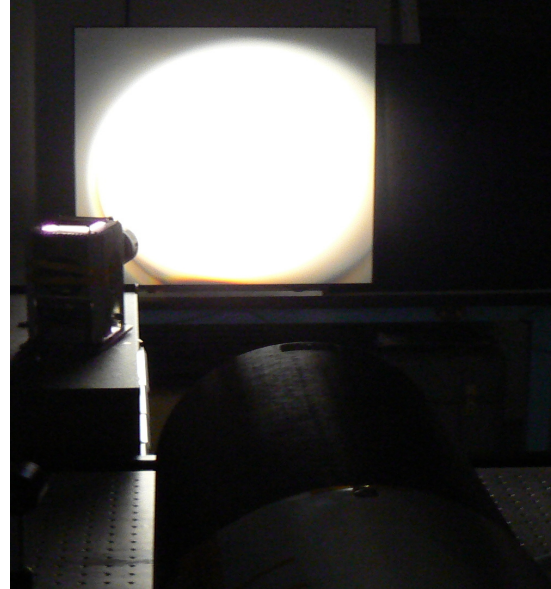
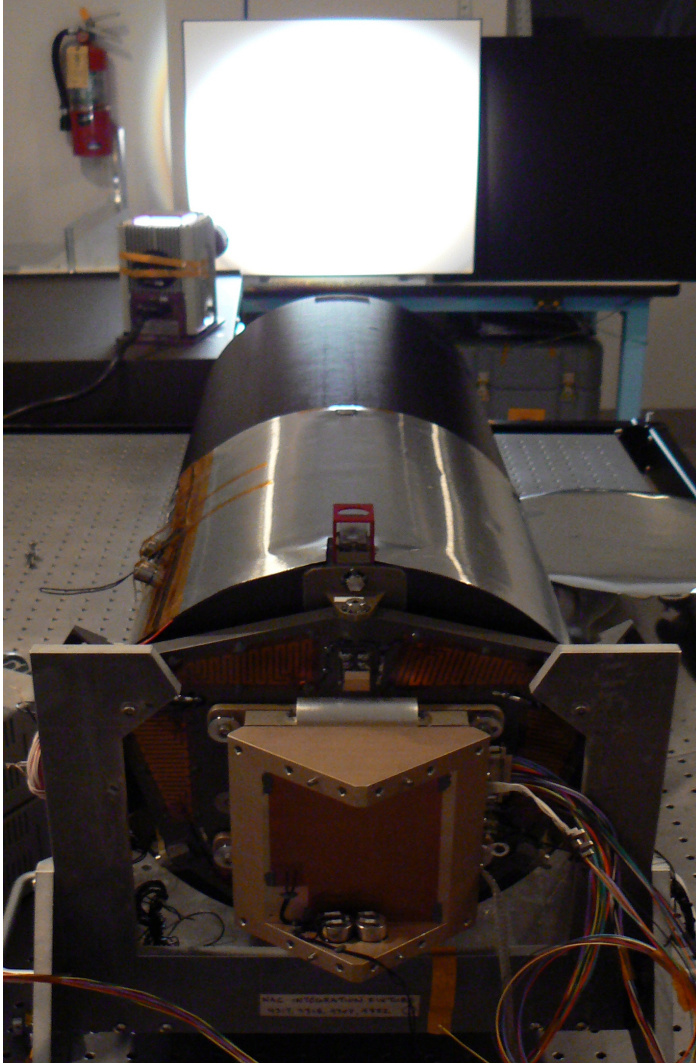
http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080206-geometrical/nacgeometrical_full.doc

NACFU1 detector linearity calibration with QTH lamp and Spectralon panel





Data were taken 2/7/2008



The quartz tungsten halogen (QTH) lamp is powered by a regulated dc current power supply, and the brightness of the

QTH lamp is highly constant with time. The exposure time given in the embedded ascii header of each .ddd file is believed to be highly accurate. In the detector linearity test, images are taken at multiple exposure times. The light source is constant, so it's possible to plot the DN as a function of relative number of photons detected (detector linearity) or line-to-line standard deviation of DN as a function of relative number of photons detected (photon transfer curve, or PTC). Repeating the data set at different lamp current, and dark, allows one to check for exposure time offset as well as DN offset, and to see if the linearity or PTC changes with frame rate. Note that for the NAC, the exposure time always equals the frame time.

The source is a fairly uniform flat field, but it's not vital that it be accurately flat for linearity and PTC.

For detector linearity and PTC calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN.

Spectroradiometer scans are taken to verify that the panel is of constant brightness. The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value. The spectroradiometer is **not** accurate >700 nm. We believe the spectroradiometer is repeatable at all wavelengths, But this has not been carefully verified.

Calibration parameters				NAC parameters							
Filename	QTH current (A)	Potentially useful	Dark	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N10dQb7.ddd	8.3	No	Shuttered	Before lunch	0	Lin1	200	73	111	0	0.337
N10dQb8.ddd	8.3	No	Shuttered		0	Lin1	200	73	111	0	0.337
N10dQb9.ddd	8.3	No	Shuttered		0	Lin1	200	73	111	0	0.337
N10dQ10.ddd	8.3	No	Shuttered		0	Lin1	200	73	111	0	0.337
Spectroradiometer scan srn10cQb00.txt				After lunch							
N10cQc0.ddd	8.3	Yes		After lunch	0	Lin16	200	73	111	3200	27.617
N10cQc1.ddd	8.3	Yes			0	Lin16	200	73	111	0	0.337
N10cQc2.ddd	8.3	Yes			0	Lin16	200	73	111	400	3.747
N10cQc3.ddd	8.3	Yes			0	Lin16	200	73	111	800	7.157
N10cQc4.ddd	8.3	Yes			0	Lin16	200	73	111	50	0.764
N10cQc5.ddd	8.3	Yes			0	Lin16	200	73	111	1800	15.682
N10cQc6.ddd	8.3	Yes			0	Lin16	200	73	111	1800	15.682
N10cQc7.ddd	8.3	Yes			0	Lin16	200	73	111	100	1.19
N10cQc8.ddd	8.3	Yes			0	Lin16	200	73	111	4095	35.246
N10cQc9.ddd	8.3	Yes			0	Lin16	200	73	111	200	2.042
N10cQc10.ddd	8.3	Yes			0	Lin16	200	73	111	3600	31.027
N10cQc11.ddd	8.3	Yes			0	Lin16	200	73	111	1200	10.567
N10cQc12.ddd	8.3	Yes			0	Lin16	200	73	111	2400	20.797
N10cQc13.ddd	8.3	Yes			0	Lin16	200	73	111	2800	24.207
N10cQc14.ddd	8.3	Yes			0	Lin16	200	73	111	3000	25.912
N10cQc15.ddd	8.3	Yes			0	Lin16	200	73	111	3400	29.322
Spectroradiometer scan srn10cQb01.txt											
N10cQd0.ddd	8.3	Yes			10		200			3200	27.617
N10cQd1.ddd	8.3	Yes			30		200			3200	27.617
N10cQd2.ddd	8.3	Yes			10		200			3200	27.617
N10cQd3.ddd	8.3	Yes			30		200			3200	27.617
N10cQd4.ddd	8.3	Yes			10		200			0	0.337
N10cQd5.ddd	8.3	Yes			30		200			0	0.337

...insert additional filenames and data, starting with page 19 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080206to8-CalLog.pdf>

N10cQj25.ddd	6 Yes	30	200	2800	24.207
N10cQj26.ddd	6 Yes	10	200	3000	25.912
N10cQj27.ddd	6 Yes	30	200	3000	25.912
N10cQj28.ddd	6 Yes	10	200	3400	29.322
N10cQj29.ddd	6 Yes	30	200	3400	29.322

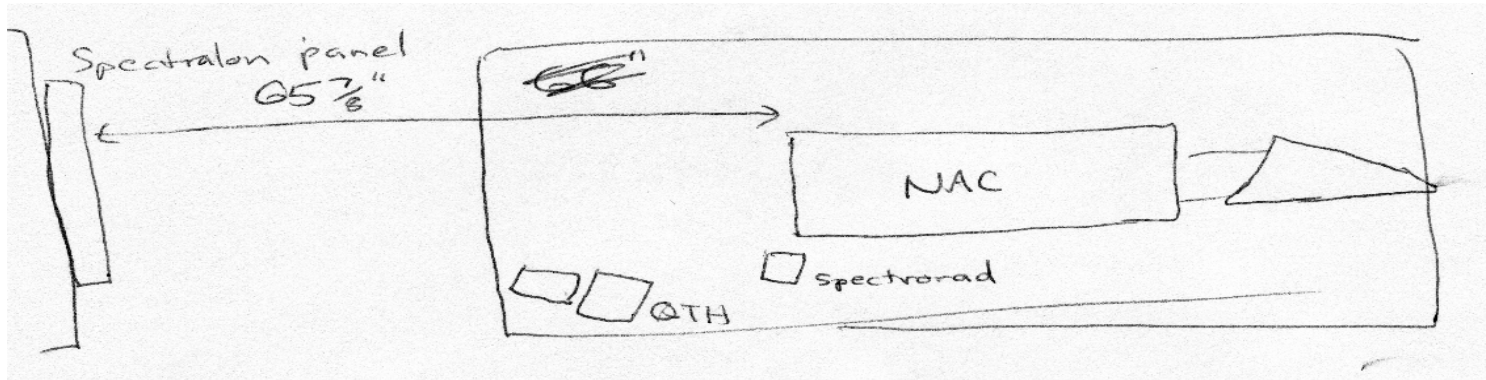
Spectroradiometer scan srn10cQc02.txt

Analysis available as of 6/26/2008

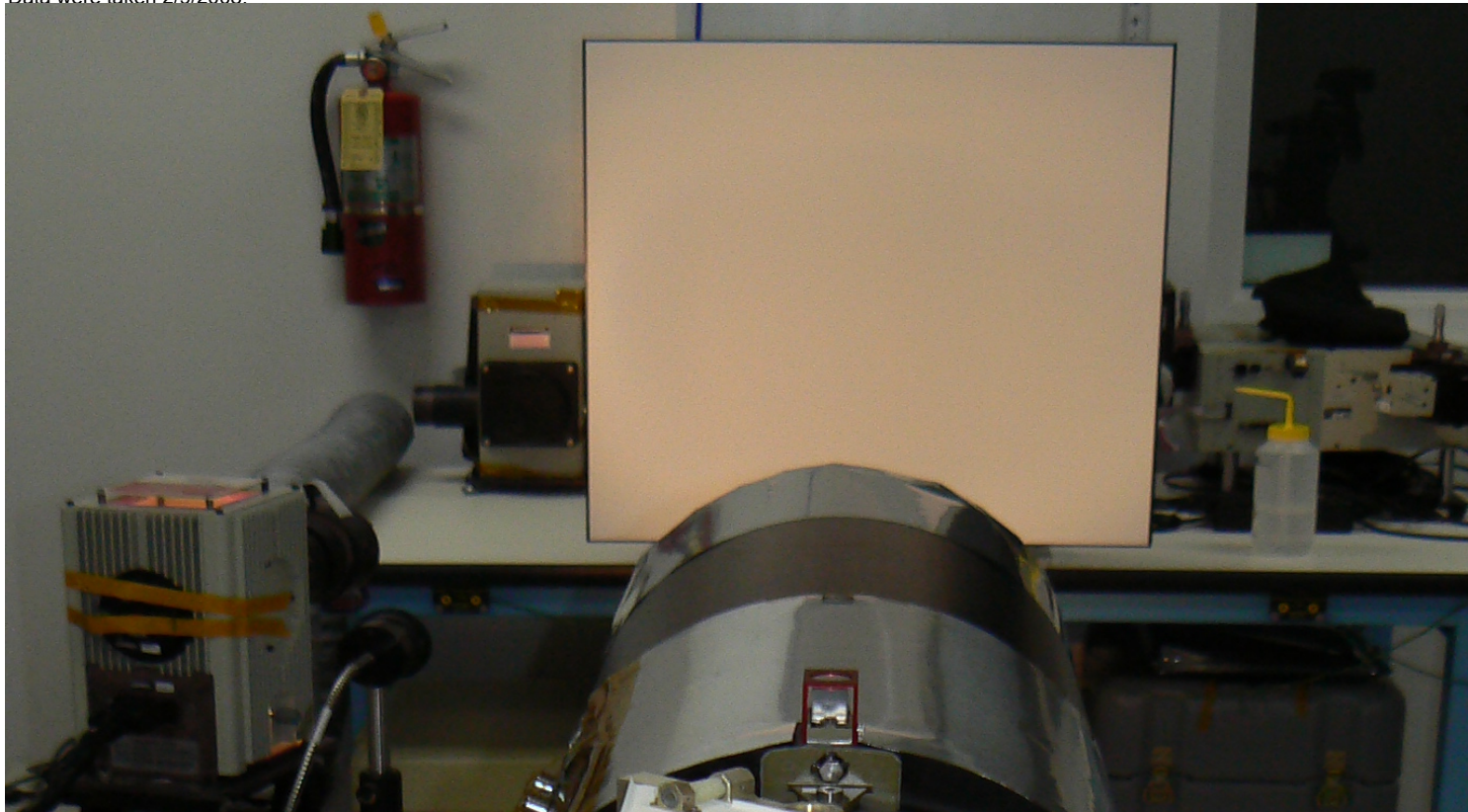
The photon transfer curve analysis for this and other data is at <http://roc.sese.asu.edu/WORK/CALB/NAC1/photontransfercurve/index.html>.

Linearity analysis was done with other NAC 1 data.

NACFU1 detector linearity calibration with QTH lamp and Spectralon panel



Data were taken 2/9/2008.





The quartz tungsten halogen (QTH) lamp is powered by a regulated dc current power supply, and the brightness of the QTH lamp is highly constant with time. The exposure time given in the embedded ascii header of each .ddd file is believed to be highly accurate. In the detector linearity test, images are taken at multiple exposure times. The light source is constant, so it's possible to plot the DN as a function of relative number of photons detected (detector linearity) or line-to-line standard deviation of DN as a function of relative number of photons detected (photon transfer curve, or PTC). Repeating the data set at different lamp current, and dark, allows one to check for exposure time offset as well as DN offset, and to see if the linearity or PTC changes with frame rate. Note that for the NAC, the exposure time always equals the frame time.

The source is a fairly uniform flat field, but it's not vital that it be accurately flat for linearity and PTC.

For detector linearity and PTC calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN.

Spectroradiometer scans are taken to verify that the panel is of constant brightness. The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value. The spectroradiometer is **not** accurate >700 nm. We believe the spectroradiometer is repeatable at all wavelengths, But this has not been carefully verified.

This data set is larger than the earlier set taken with the QTH shining on the Spectralon panel. In this set, the whole set of exposure times is repeated at different DAC levels, to check whether the DAC level affects the linearity. As far as we can tell, it doesn't, it just shifts DN by a constant over the entire range. Because of the offsets caused by the DAC, most of the images have high DN, including the darks, so the lin1 companding table isn't used very much. The QTH lamp current is 7.4 amperes for all these data.

Calibration parameters			NAC parameters						
Filename	Dark	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N10cQk2.ddd			0 Lin16		200	53	98	4095	35.246
Spectroradiometer scan srn10cQd02.txt, capped (dark), scope mode									
Spectroradiometer scan srn10cQd03.txt, scope mode									

qth_panel_dac

N10cQl00.ddd	10	200	3200	27.617
N10cQl01.ddd	30	200	3200	27.617
N10cQl02.ddd	10	200	0	0.337
N10cQl03.ddd	30	200	0	0.337
N10cQl04.ddd	10	200	400	3.747
N10cQl05.ddd	30	200	400	3.747
N10cQl06.ddd	10	200	800	7.157
N10cQl07.ddd	30	200	800	7.157
N10cQl08.ddd	10	200	50	0.764
N10cQl09.ddd	30	200	50	0.764
N10cQl10.ddd	10	200	1800	15.682
N10cQl11.ddd	30	200	1800	15.682
N10cQl12.ddd	10	200	100	1.19
N10cQl13.ddd	30	200	100	1.19
N10cQl14.ddd	10	200	4095	35.246
N10cQl15.ddd	30	200	4095	35.246
N10cQl16.ddd	10	200	200	2.042
N10cQl17.ddd	30	200	200	2.042
N10cQl18.ddd	10	200	3600	31.027
N10cQl19.ddd	30	200	3600	31.027
N10cQl22.ddd	10	200	1200	10.567
N10cQl23.ddd	30	200	1200	10.567
N10cQl24.ddd	10	200	2400	20.797
N10cQl25.ddd	30	200	2400	20.797
N10cQl26.ddd Shuttered	10	200	0	0.337
N10cQl27.ddd Shuttered	30	200	0	0.337
Spectroradiometer scan srn10cQd04.txt (scope mode?)				
N10tQa0.ddd Shuttered	0 Lin1	199	53	98
N10cQm0.ddd Shuttered	10	199	0	0.337
N10cQm1.ddd Shuttered	30	199	0	0.337
N10cQm2.ddd Shuttered	10	199	3200	27.617
N10cQm3.ddd Shuttered	30	199	3200	27.617
N10cQm4.ddd Shuttered	10	199	0	0.337
N10cQm5.ddd Shuttered	30	199	0	0.337

...insert additional filenames and data, starting with page 4 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080209-CalLog.pdf>

N10cQs24.ddd	10	180	2400	20.797
N10cQs25.ddd	30	180	2400	20.797
Spectroradiometer scan srn10cQd10.txt (scope mode?)				
N10cQs26.ddd Shuttered	10	180	0	0.337
N10cQs27.ddd Shuttered	30	180	0	0.337
N10cQs32.ddd Shuttered, lamp off	10	180	0	0.337
N10cQs33.ddd Shuttered, lamp off	30	180	0	0.337

Analysis available as of 6/27/2008

Linearity analysis is at <http://lroc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080209-PTC/index.html>

Photon transfer curve analysis is at <http://lroc.sese.asu.edu/WORK/CALB/NAC1/photontransfercurve/index.html>

NACFU1 detector linearity calibration with dark source

Data were taken 2/8/2008.

In the detector linearity test, images are taken at multiple exposure times.

For NAC dark images at room temperature and lower, dark current is small and variations of the detector offset are more important.

Therefore, this data set mostly gives variations in the offset rather than dark current.

This data set was taken pretty soon after the NAC was powered up, so it includes variation in offset with clock time.

Note that for the NAC, the exposure time always equals the frame time.

For darks, mode 0, lin1 data gives fully accurate DN for DN<256.

All these images were taken with the lamps off and the NAC shuttered.

Calibration parameters		NAC parameters			Dc offset B	Exp command	Exposure time (ms)	
Filename	Notes	Mode	Companding tat DAC	Dc offset A				
N10dLa0.ddd		0 Lin1		200	73	111	3200	27.617

...insert additional filenames and data, starting with page 27 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080206to8-CalLog.pdf>

This was when I first realized that the NAC detector offset was so sensitive to temperature and there are several pages of notes on what to do about it.

N10dLc20.ddd		0 Lin1		200	51	93	3400	29.322
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Analysis available as of 6/26/2008

This NAC 1 data is not yet analyzed, but it would be at <http://roc.sese.asu.edu/WORK/CALB/NAC1/darkanalysis/index.html>.

Similar NAC 2 data analysis results are at <http://roc.sese.asu.edu/WORK/CALB/NAC2/darkanalysis/figs/NAC2-dark-heatingup.pdf>, which shows warm-up, and at <http://roc.sese.asu.edu/WORK/CALB/NAC2/darkanalysis/figs/NAC2-dark-vs-integration.pdf>, which shows offset as a function of exposure

Time, and a small amount of dark current.

NACFU1 detector linearity calibration with dark source

Data were taken 4/13/2008.

In the detector linearity test, images are taken at multiple exposure times.

For NAC dark images at room temperature and lower, dark current is small and variations of the detector offset are more important.

Therefore, this data set mostly gives variations in the offset rather than dark current.

The NAC had been powered up for 2.5 hours before these images were taken, so there shouldn't be much variation in offset with wall clock time.

Note that for the NAC, the exposure time always equals the frame time.

For darks, mode 0, lin1 data gives fully accurate DN for DN<256.

All these images were taken with the lamps off and the NAC shuttered.

Calibration parameters		NAC parameters						
Filename	Notes	Mode	Companding tat DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N10dLe0.ddd		0 Lin1		200	77	124	3200	27.617

...insert additional filenames and data, starting with page 15 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC2&NAC1-20080413-CalLog.pdf>

N10dLc17.ddd		0 Lin1		200	77	124	0	0.337
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A very similar data set is described in the stray_sphere worksheet; it's images N13dXa0.ddd through N13dXa13.ddd.

A very similar data set is described in the qth_sphere worksheet; it's images N10dSa0.ddd through N10dSa15.ddd.

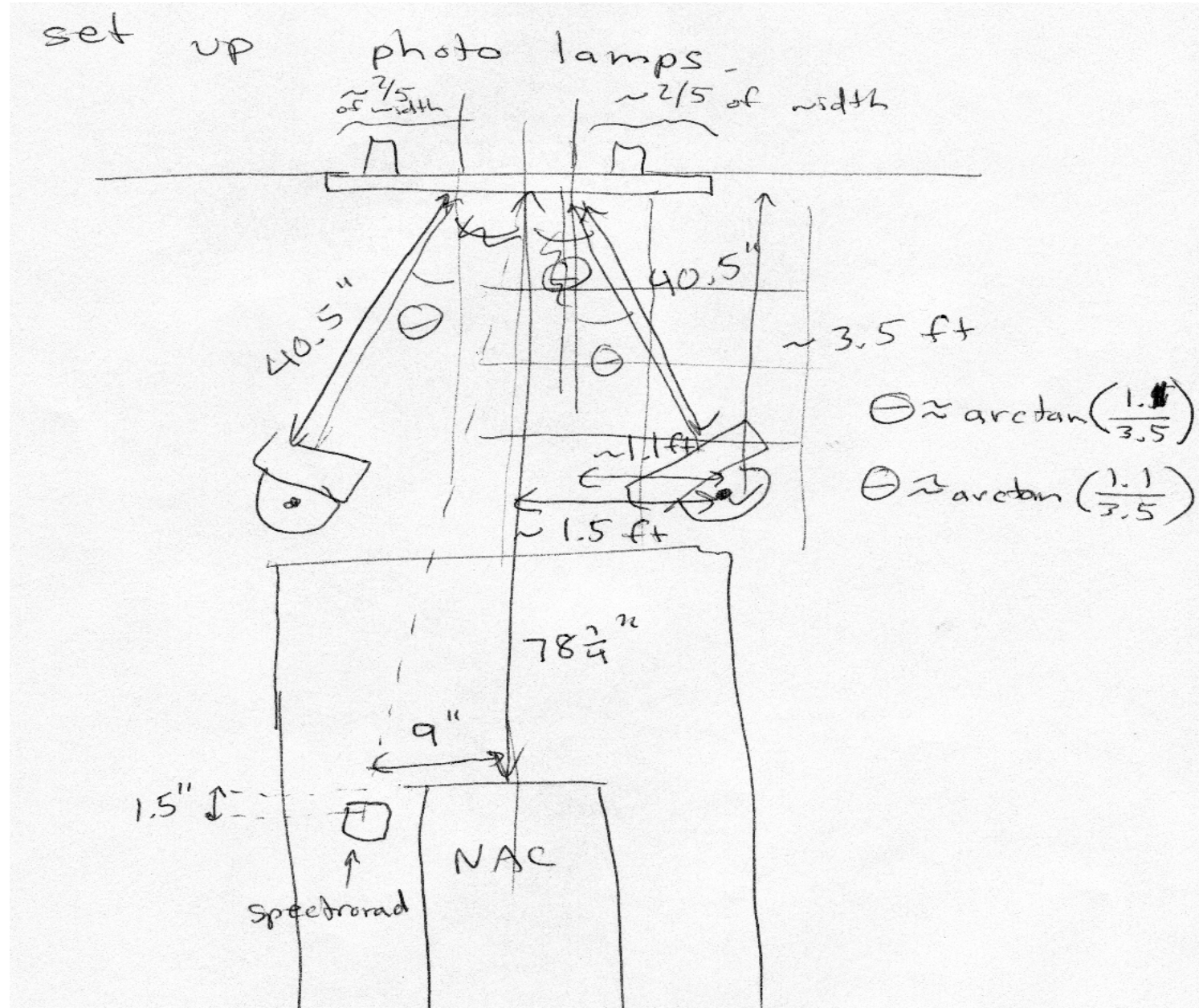
Analysis available as of 7/23/2008

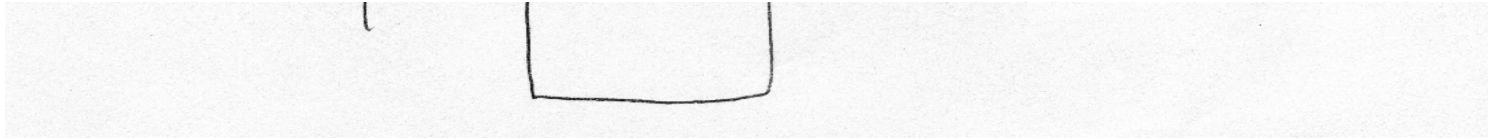
This NAC 1 data is not yet analyzed, but it would be at <http://roc.sese.asu.edu/WORK/CALB/NAC1/darkanalysis/index.html>.

Similar NAC 2 data analysis results are at <http://roc.sese.asu.edu/WORK/CALB/NAC2/darkanalysis/figs/NAC2-dark-heatingup.pdf>, which shows warm-up, and at <http://roc.sese.asu.edu/WORK/CALB/NAC2/darkanalysis/figs/NAC2-dark-vs-integration.pdf>, which shows offset as a function of exposure

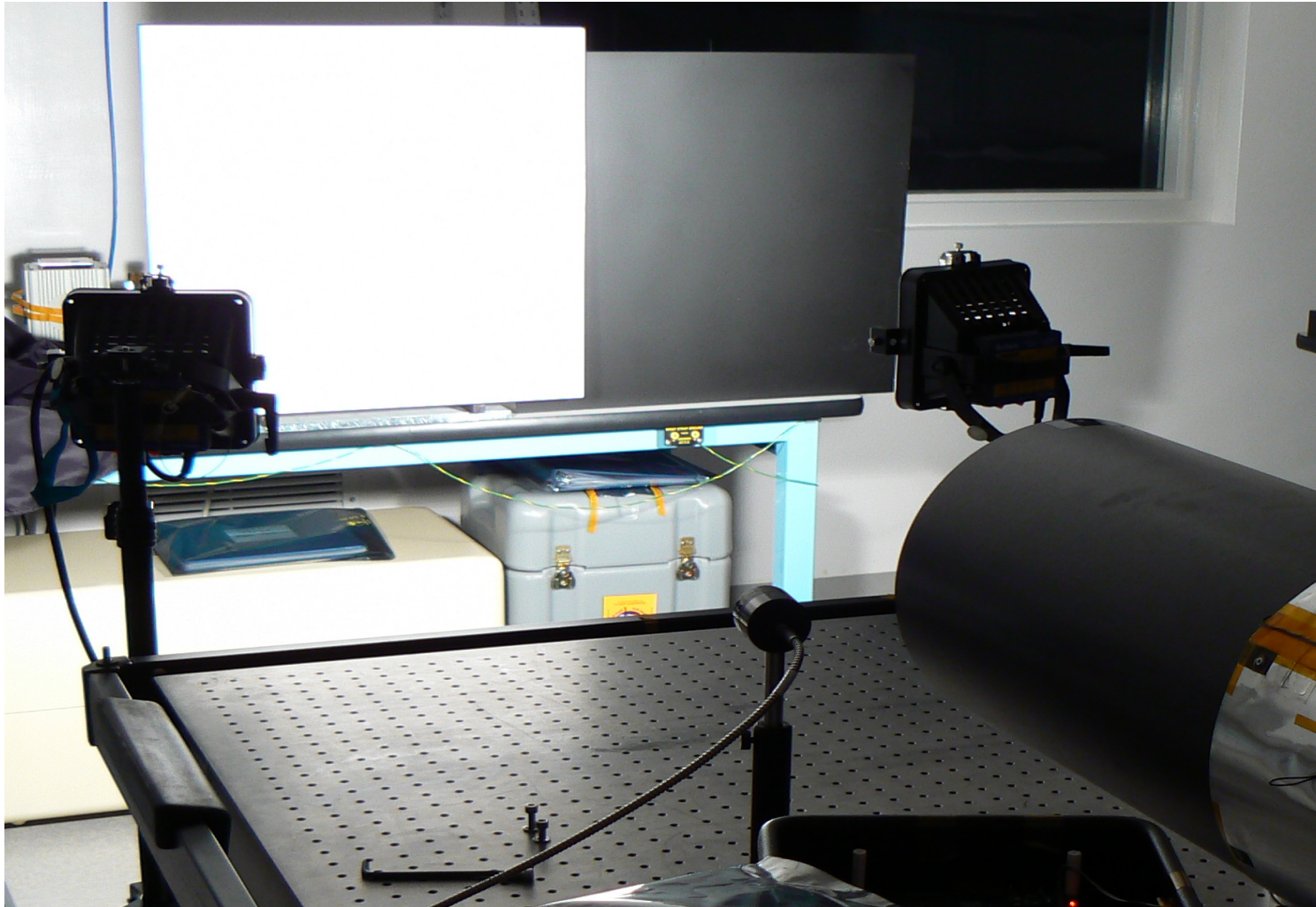
Time, and a small amount of dark current.

NACFU1 detector linearity calibration with photo flood lamps and Spectralon panel





Data were taken 2/8/2008.



The two photo flood lamps provide very bright and very uniform illumination of the Spectralon panel. The photo flood lamps are driven directly by AC wall current, and they suffer from 3 kinds of variability:

1. Variability of the AC wall current voltage amplitude over tens of minutes to hours, making the overall brightness nonrepeatable by a few percent.
2. The actual 120 Hz variation in lamp filament temperature due to the 120 Hz variation in electric power due to the 60 Hz variation in voltage. This gives rise to horizontal stripes in the images with an amplitude of about 3%.
3. The lamps are very hot and one sees heat waves rising from them. The lensing causes variability in one photo lamp with respect to another. This leads to gradients of ~1% in the panel uniformity, varying with a timescale of a couple of tenths of a second. This averages out to no gradient over many lines and many images.

So, this source is very good for a flat field, but for a linearity or PTC, variability type 1 limits the accuracy. However, it's much brighter than the QTH illuminated sources, so it gives information on the detector linearity at high frame rates and shows there is no significant offset in exposure time.

For detector linearity and PTC calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN.

Spectroradiometer scans are taken to verify that the panel is of constant brightness. The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value. The spectroradiometer is **not** accurate >700 nm. We believe the spectroradiometer is repeatable at all wavelengths, But this has not been carefully verified.

Calibration parameters			NAC parameters					
Filename	Dark	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)
Spectroradiometer scan srn10cLb00.txt								
N10cLa0.ddd			0 Lin16		200	51	93	60
Spectroradiometer scan srn10cLb01.txt								0.849
N10cLa1.ddd			0 Lin16		200	51	93	0
N10cLa2.ddd			0 Lin16		200	51	93	400
N10cLa3.ddd			0 Lin16		200	51	93	800
N10cLa4.ddd			0 Lin16		200	51	93	50

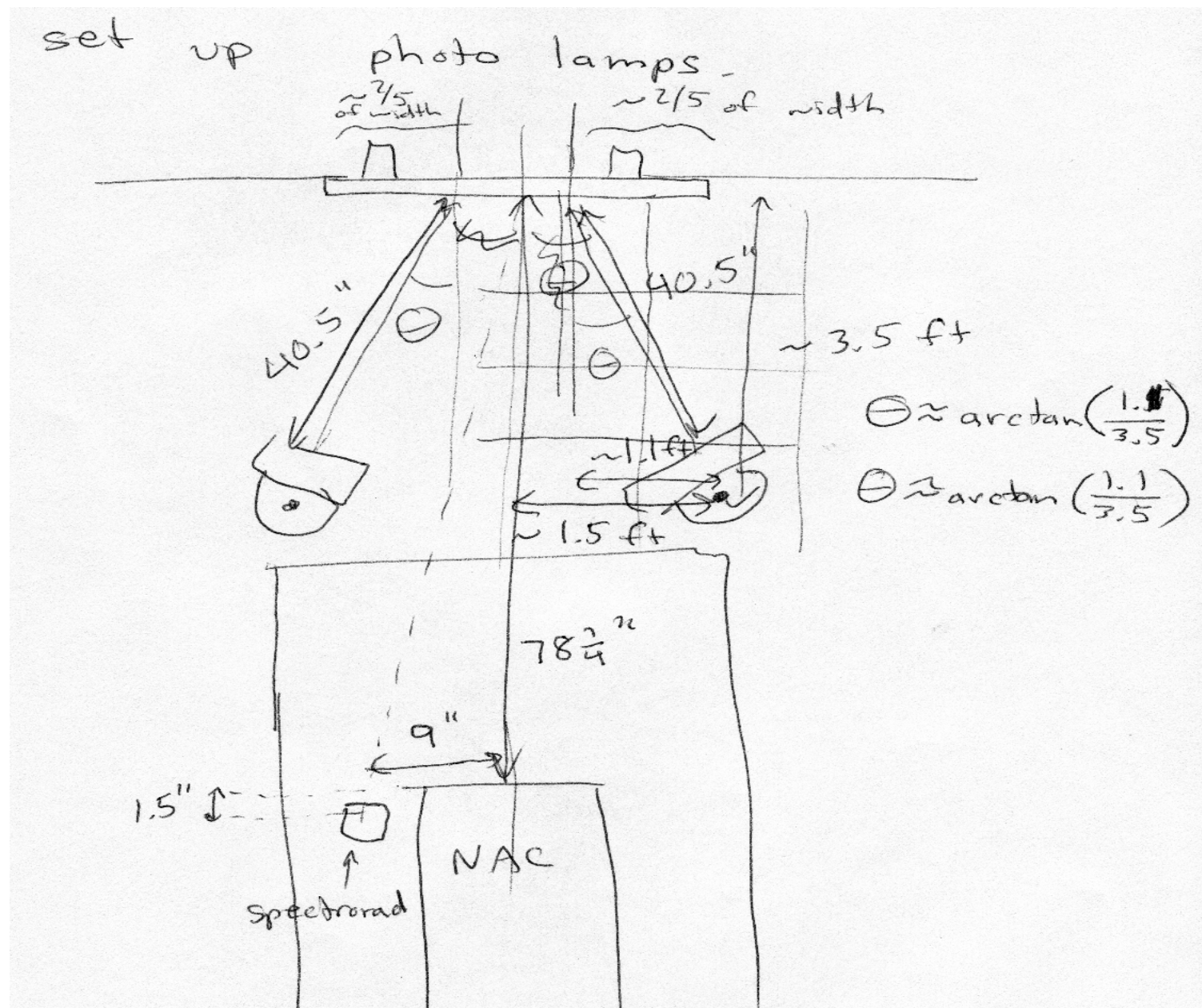
...insert additional filenames and data, starting with page 36 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080206to8-CalLog.pdf>

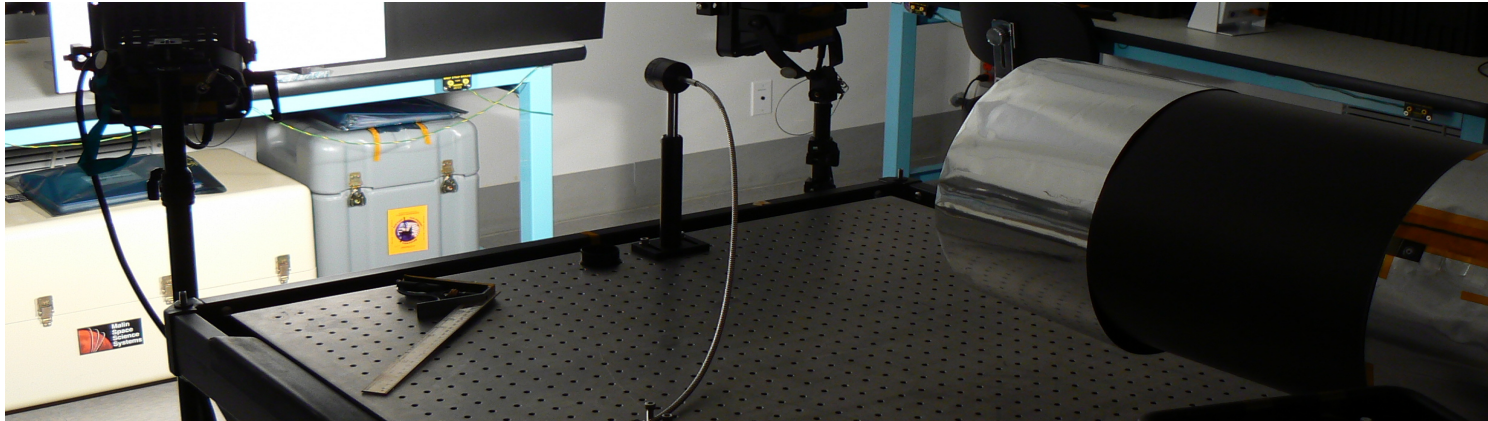
Spectroradiometer scan srn10cLc11.txt								
N10cLc2.ddd			0 Lin16		200	51	93	300
Spectroradiometer scan srn10cLc12.txt								2.895

Analysis available as of 6/26/2008

<http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080208-1-PTC/index.html>

NACFU1 flat field calibration with photo flood lamps and Spectralon panel





For darks, the NAC was shuttered as shown, plus the 24"x24" black plate was put in front of the shuttered aperture.

The two photo flood lamps provide very bright and very uniform illumination of the Spectralon panel. The photo flood lamps are driven directly by AC wall current, and they suffer from 3 kinds of variability:

1. Variability of the AC wall current voltage amplitude over tens of minutes to hours, making the overall brightness nonrepeatable by a few percent.
2. The actual 120 Hz variation in lamp filament temperature due to the 120 Hz variation in electric power due to the 60 Hz variation in voltage. This gives rise to horizontal stripes in the images with an amplitude of about 3%.
3. The lamps are very hot and one sees heat waves rising from them. The lensing causes variability in one photo lamp with respect to another. This leads to gradients of ~1% in the panel uniformity, varying with a timescale of a couple of tenths of a second. This averages out to no gradient over many lines and many images.

For flat field calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN. Unfortunately, for these data we only have mode 0, lin16, because the mode 10 and mode 30 images have 1280 lines and we were not able to get good images from the GSE that had more than 128 lines.

Spectroradiometer scans are taken to verify that the panel is flat and to monitor brightness changes with time.

The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value.

The spectroradiometer is **not** accurate >700 nm. We believe it is repeatable at all wavelengths, but this has not been carefully verified.

Calibration parameters			NAC parameters				
Filename	Dark	Notes	Mode	Companding tat DAC	Dc offset A	Dc offset B	Exp command Exposure time (ms)
Spectroradiometer scan srn11f00.txt in scope mode, capped (dark)							
Spectroradiometer scan srn11f01.txt in scope mode							
Spectroradiometer scan srn11f02.txt							
Next set of spectroradiometer scans are over a grid given in the second drawing above							
Spectroradiometer scan srn11f03.txt							
Spectroradiometer scan srn11f04.txt							
Spectroradiometer scan srn11f05.txt							

Spectroradiometer scan srn11f06.txt
 Spectroradiometer scan srn11f07.txt
 Spectroradiometer scan srn11f08.txt
 Spectroradiometer scan srn11f09.txt
 Spectroradiometer scan srn11f10.txt
 Spectroradiometer scan srn11f11.txt
 Spectroradiometer scan srn11f12.txt
 Spectroradiometer scan srn11f13.txt

N11fLa5.ddd	0 Lin16	200	51	93	40	0.678
N11fLa6.ddd	0 Lin16	200	51	93	40	0.678

...insert additional filenames and data, starting with page 41 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080206to8-CalLog.pdf>

N11fLa46.ddd Shuttered and dark plate	0 Lin16	200	51	93	140	1.531
Spectroradiometer scan srn11f14.txt						

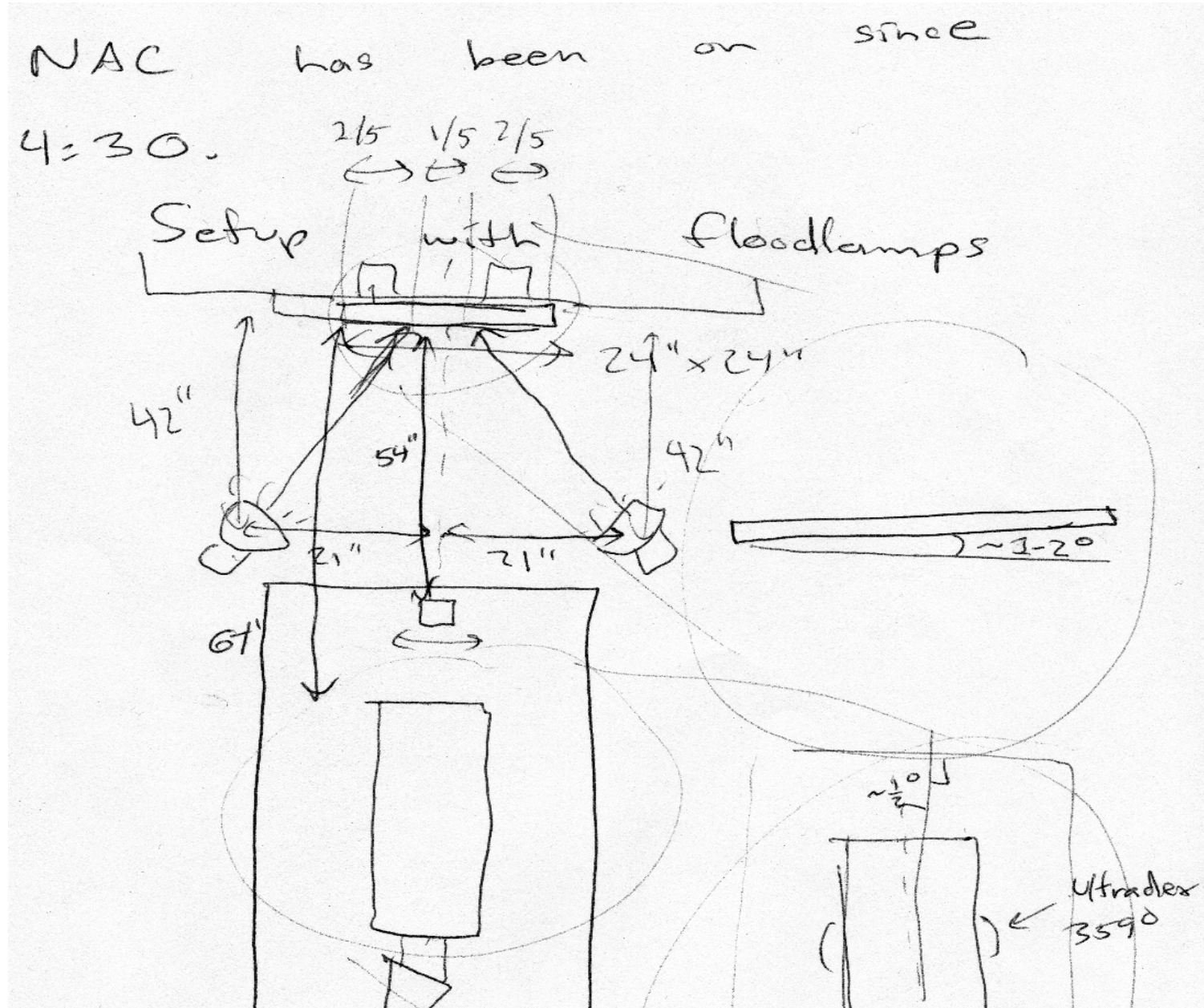
Analysis available as of 6/26/2008

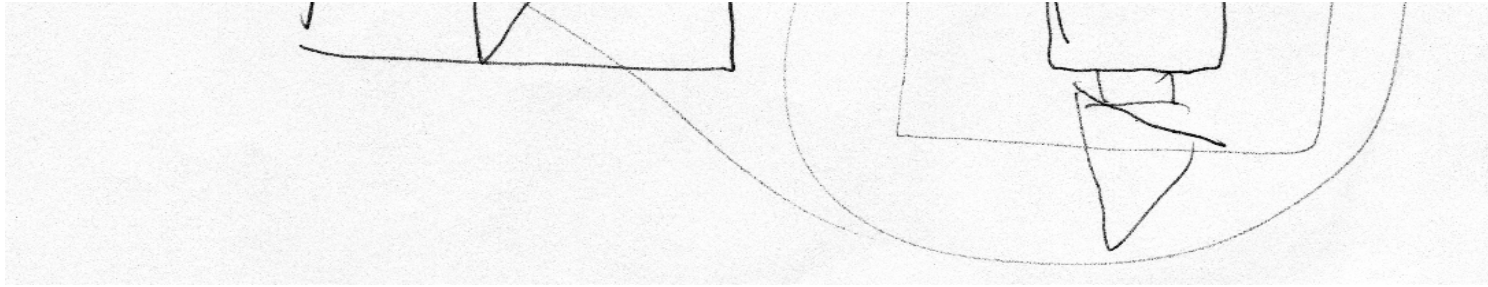
<http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080208-2-flatfield/index.html>

Also, as of 7/29/2008, the full masked pixel, dark, and offset subtraction for the flight calibration pipeline is not yet implemented.

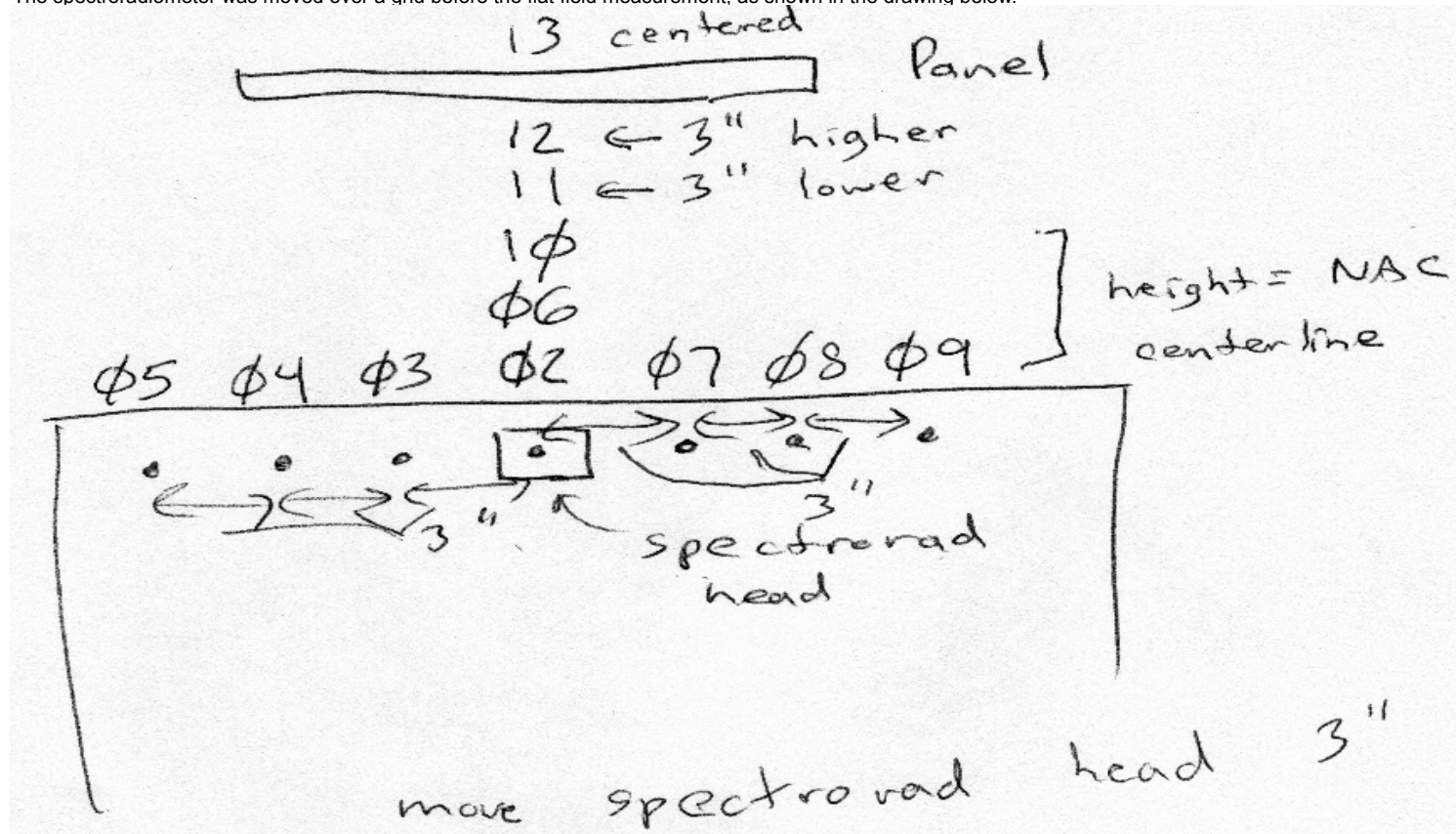
The flat fields will change slightly from the ones posted on the Web site when the flight pipeline is completed.

NACFU1 flat field calibration with photo flood lamps and Spectralon panel





The spectroradiometer was moved over a grid before the flat field measurement, as shown in the drawing below.



Data were taken 2/12/2008.

For darks, the NAC was shuttered, plus the 24"x24" black plate was put in front of the shuttered aperture.

The two photo flood lamps provide very bright and very uniform illumination of the Spectralon panel. The photo flood lamps are driven directly by AC wall current, and they suffer from 3 kinds of variability:

1. Variability of the AC wall current voltage amplitude over tens of minutes to hours, making the overall brightness nonrepeatable by a few percent.
2. The actual 120 Hz variation in lamp filament temperature due to the 120 Hz variation in electric power due to the 60 Hz variation in voltage. This gives rise to horizontal stripes in the images with an amplitude of about 3%.
3. The lamps are very hot and one sees heat waves rising from them. The lensing causes variability in one photo lamp with respect to another. This leads to gradients of ~1% in the panel uniformity, varying with a timescale of a couple of tenths of a second. This averages out to no gradient over many lines and many images.

For flat field calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN. This second set of flat field data has good images in mode 10 and mode 30, unlike the first set.

Spectroradiometer scans are taken to verify that the panel is flat and to monitor brightness changes with time.

The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value.

The spectroradiometer is **not** accurate >700 nm. We believe it is repeatable at all wavelengths, but this has not been carefully verified.

Calibration parameters

Filename Dark Notes

NAC parameters

Mode Companding tat DAC Dc offset A Dc offset B Exp command Exposure time (ms)

Spectroradiometer scan srn11fLd00.txt in scope mode, capped (dark)

Spectroradiometer scan srn11fLd01.txt in scope mode

Next set of spectroradiometer scans are over a grid given in the second drawing above

Spectroradiometer scan srn11fLd02.txt

Spectroradiometer scan srn11fLd03.txt

Spectroradiometer scan srn11fLd04.txt

Spectroradiometer scan srn11fLd05.txt

Spectroradiometer scan srn11fLd06.txt

Spectroradiometer scan srn11fLd07.txt

Spectroradiometer scan srn11fLd08.txt

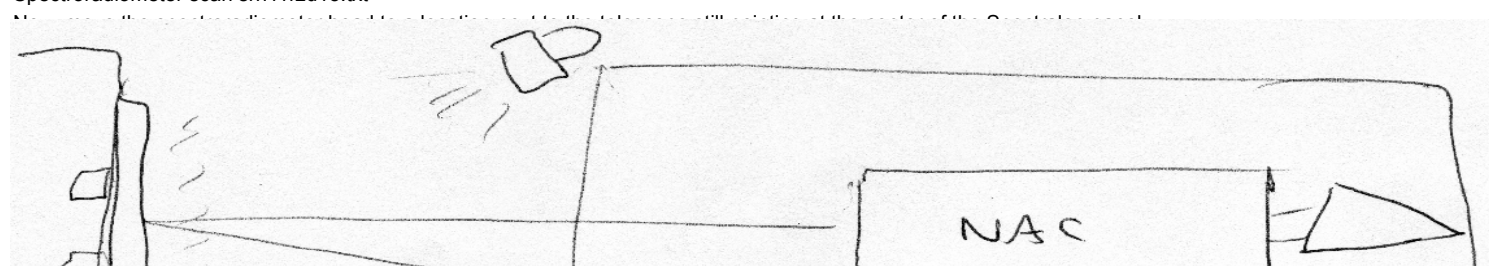
Spectroradiometer scan srn11fLd09.txt

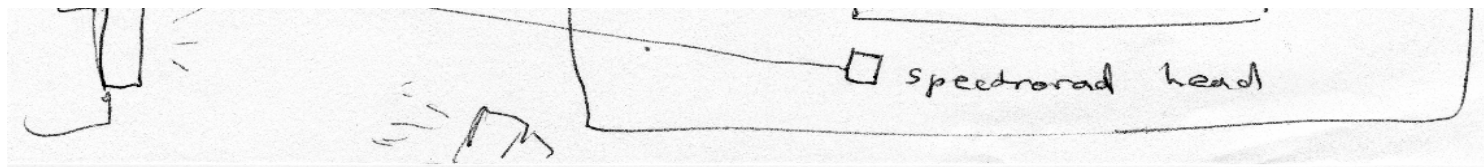
Spectroradiometer scan srn11fLd10.txt

Spectroradiometer scan srn11fLd11.txt

Spectroradiometer scan srn11fLd12.txt

Spectroradiometer scan srn11fLd13.txt





Spectroradiometer scan srn11fLd14.txt

N11dLb0.ddd	Shuttered and dark plate	0 Lin1	200	0	0	0	0.337
N11dLb4.ddd	Shuttered and dark plate	0 Lin1	200	20	70	40	0.678
N11dLb5.ddd	Shuttered and dark plate	0 Lin1	200	20	70	140	1.531
N11dLb6.ddd	Shuttered and dark plate	0 Lin16	200	20	70	0	0.337
N11dLb7.ddd	Shuttered and dark plate	0 Lin16	200	20	70	40	0.678
N11dLb8.ddd	Shuttered and dark plate	0 Lin16	200	20	70	140	1.531
N11dLb9.ddd	Shuttered and dark plate	10	200			0	0.337
N11dLb9.ddd	Shuttered and dark plate	30	200			0	0.337
N11dLb10.ddd	Shuttered and dark plate	10	200			40	0.678
N11dLb11.ddd	Shuttered and dark plate	30	200			40	0.678
N11dLb12.ddd	Shuttered and dark plate	10	200			140	1.531
N11dLb13.ddd	Shuttered and dark plate	30	200			140	1.531
N11fLe0.ddd		0 Lin16	200	20	70	0	0.337
N11fLe1.ddd		0 Lin16	200	20	70	40	0.678
N11fLe2.ddd		0 Lin16	200	20	70	140	1.531
N11fLe3.ddd		10	200			0	0.337
N11fLe4.ddd		10	200			0	0.337
N11fLe5.ddd		10	200			0	0.337

...insert additional filenames and data, starting with page 5 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080212-CalLog.pdf>

N11fLg39.ddd		30	200			140	1.531
Spectroradiometer scan srn11fLd19.txt							
N11dLc0.ddd	Shuttered and dark plate	0 Lin1	200	20	70	0	0.337
N11dLc1.ddd	Shuttered and dark plate	0 Lin16	200	20	70	0	0.337
N11dLc2.ddd	Shuttered and dark plate	10	200			0	0.337
N11dLc3.ddd	Shuttered and dark plate	30	200			0	0.337
N11dLc4.ddd	Shuttered and dark plate	0 Lin1	200	20	70	40	0.678
N11dLc5.ddd	Shuttered and dark plate	0 Lin16	200	20	70	40	0.678
N11dLc6.ddd	Shuttered and dark plate	10	200			40	0.678
N11dLc7.ddd	Shuttered and dark plate	30	200			40	0.678
N11dLc8.ddd	Shuttered and dark plate	0 Lin1	200	20	70	140	1.531
N11dLc9.ddd	Shuttered and dark plate	0 Lin16	200	20	70	140	1.531
N11dLc10.ddd	Shuttered and dark plate	10	200			140	1.531
N11dLc11.ddd	Shuttered and dark plate	30	200			140	1.531
N11dLd0.ddd	Lamps off, shuttered, dark room	0 Lin1	200	20	70	0	0.337
N11dLd1.ddd	Lamps off, shuttered, dark room	0 Lin16	200	20	70	0	0.337

flat_field_b

N11dLd2.ddd	Lamps off, shuttered, dark room	10	200			0	0.337
N11dLd3.ddd	Lamps off, shuttered, dark room	30	200			0	0.337
N11dLd4.ddd	Lamps off, shuttered, dark room	0 Lin1	200	20	70	40	0.678
N11dLd5.ddd	Lamps off, shuttered, dark room	0 Lin16	200	20	70	40	0.678
N11dLd6.ddd	Lamps off, shuttered, dark room	10	200			40	0.678
N11dLd7.ddd	Lamps off, shuttered, dark room	30	200			40	0.678
N11dLd8.ddd	Lamps off, shuttered, dark room	0 Lin1	200	20	70	140	1.531
N11dLd9.ddd	Lamps off, shuttered, dark room	0 Lin16	200	20	70	140	1.531
N11dLd10.ddd	Lamps off, shuttered, dark room	10	200			140	1.531
N11dLd11.ddd	Lamps off, shuttered, dark room	30	200			140	1.531

Analysis available as of 7/23/2008

<http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080212-flatfield/index.html>

Some columns of numbers and plots of flat fields are posted on this site.

As of 7/29/2008, some of these numbers and plots should be taken with a grain of salt.

Mode 10 has accurate 12-bit data for even columns and mode 30 has accurate 12-bit data for odd columns.

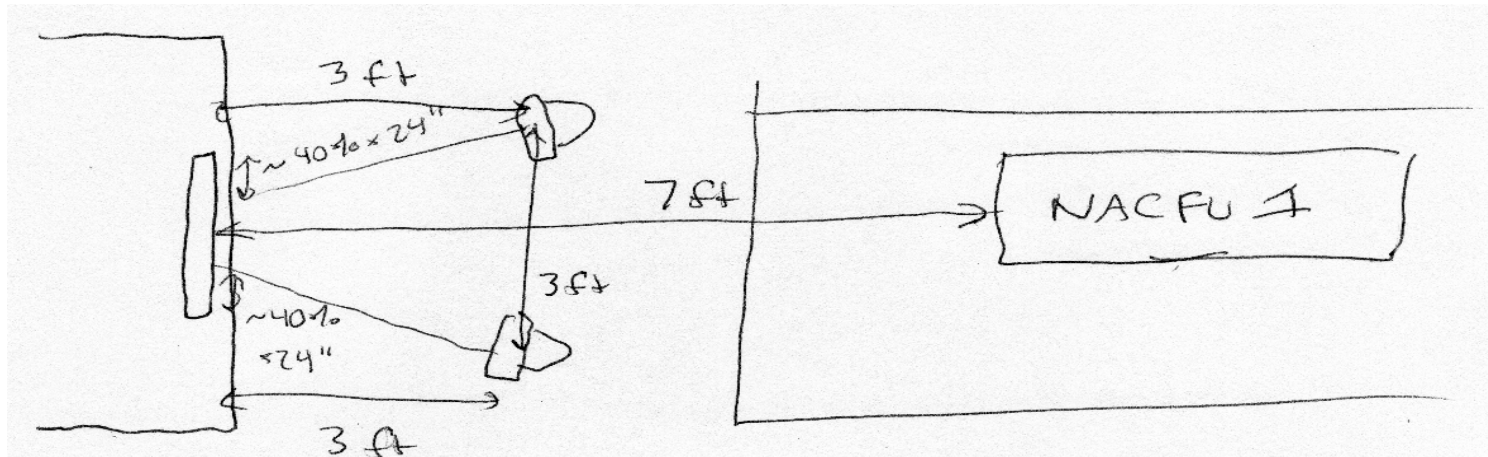
However, the plots on this website include odd columns in mode 10 and even columns in mode 30, reconstructed from 4-bit data.

These are not reliable.

Also, as of 7/29/2008, the full masked pixel, dark, and offset subtraction for the flight calibration pipeline is not yet implemented.

The flat fields will change slightly from the ones posted on the Web site when the flight pipeline is completed.

NACFU1 flat field calibration with photo flood lamps and Spectralon panel



Data were taken 4/13/2008, just after the NACFU2 calibration.





For darks, the NAC was shuttered, plus the 24"x24" black plate was put in front of the shuttered aperture.

The two photo flood lamps provide very bright and very uniform illumination of the Spectralon panel. The photo flood lamps are driven directly by AC wall current, and they suffer from 3 kinds of variability:

1. Variability of the AC wall current voltage amplitude over tens of minutes to hours, making the overall brightness nonrepeatable by a few percent.
2. The actual 120 Hz variation in lamp filament temperature due to the 120 Hz variation in electric power due to the 60 Hz variation in voltage. This gives rise to horizontal stripes in the images with an amplitude of about 3%.
3. The lamps are very hot and one sees heat waves rising from them. The lensing causes variability in one photo lamp with respect to another. This leads to gradients of ~1% in the panel uniformity, varying with a timescale of a couple of tenths of a second. This averages out to no gradient over many lines and many images.

For flat field calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN. This second set of flat field data has good images in mode 10 and mode 30, unlike the first set.

Spectroradiometer scans are taken to verify that the panel is flat and to monitor brightness changes with time. The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value. The spectroradiometer is **not** accurate >700 nm. We believe it is repeatable at all wavelengths, but this has not been carefully verified.

Calibration parameters

NAC parameters

Filename	Dark	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)
N11dLe0.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	0	0.337
N11dLe1.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	0	0.337
N11dLe2.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	0	0.337
N11dLe3.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	300	2.895
N11dLe4.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	300	2.895
N11dLe5.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	300	2.895
N11dLe6.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	40	0.678
N11dLe7.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	40	0.678
N11dLe8.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	40	0.678
N11dLe9.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	140	1.531
N11dLe10.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	140	1.531
N11dLe11.ddd	Lamps off, room lights off, shuttered			0 Lin1	200	77 124	140	1.531
Spectroradiometer scan srn11fLh00.txt in scope mode, capped (dark)								
Spectroradiometer scan srn11fLh01.txt capped (dark)								
Spectroradiometer scan srn11fLh02.txt in scope mode								
Spectroradiometer scan srn11fLh03.txt								
N11tLb0.ddd	Too bright (~200x16 DN)			0 Lin16	200	77 124	300	2.895
N11tLb1.ddd				0 Lin16	200	77 124	140	1.531
N11tLc0.ddd				0 Lin16	200	77 124	0	0.337
N11fLh0.ddd				10	200		0	0.337
N11fLh1.ddd				10	200		0	0.337
N11fLh2.ddd				10	200		0	0.337

...insert additional filenames and data, starting with page 10 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC2&NAC1-20080413-CalLog.pdf>

N11fLj39.ddd			30		200		140	1.531
Spectroradiometer scan srn11fLh04.txt in scope mode, capped (dark)								
Spectroradiometer scan srn11fLh05.txt capped (dark)								
Spectroradiometer scan srn11fLh06.txt, uses srn11fLh04.txt as dark and reference								

Analysis available as of 7/23/2008

<http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080413-1-flatfield+darktest/index.html>

Some columns of numbers and plots of flat fields are posted on this site.

As of 7/29/2008, some of these numbers and plots should be taken with a grain of salt.

Mode 10 has accurate 12-bit data for even columns and mode 30 has accurate 12-bit data for odd columns.

However, the plots on this website include odd columns in mode 10 and even columns in mode 30, reconstructed from 4-bit data.

These are not reliable.

Also, as of 7/29/2008, the full masked pixel, dark, and offset subtraction for the flight calibration pipeline is not yet implemented.

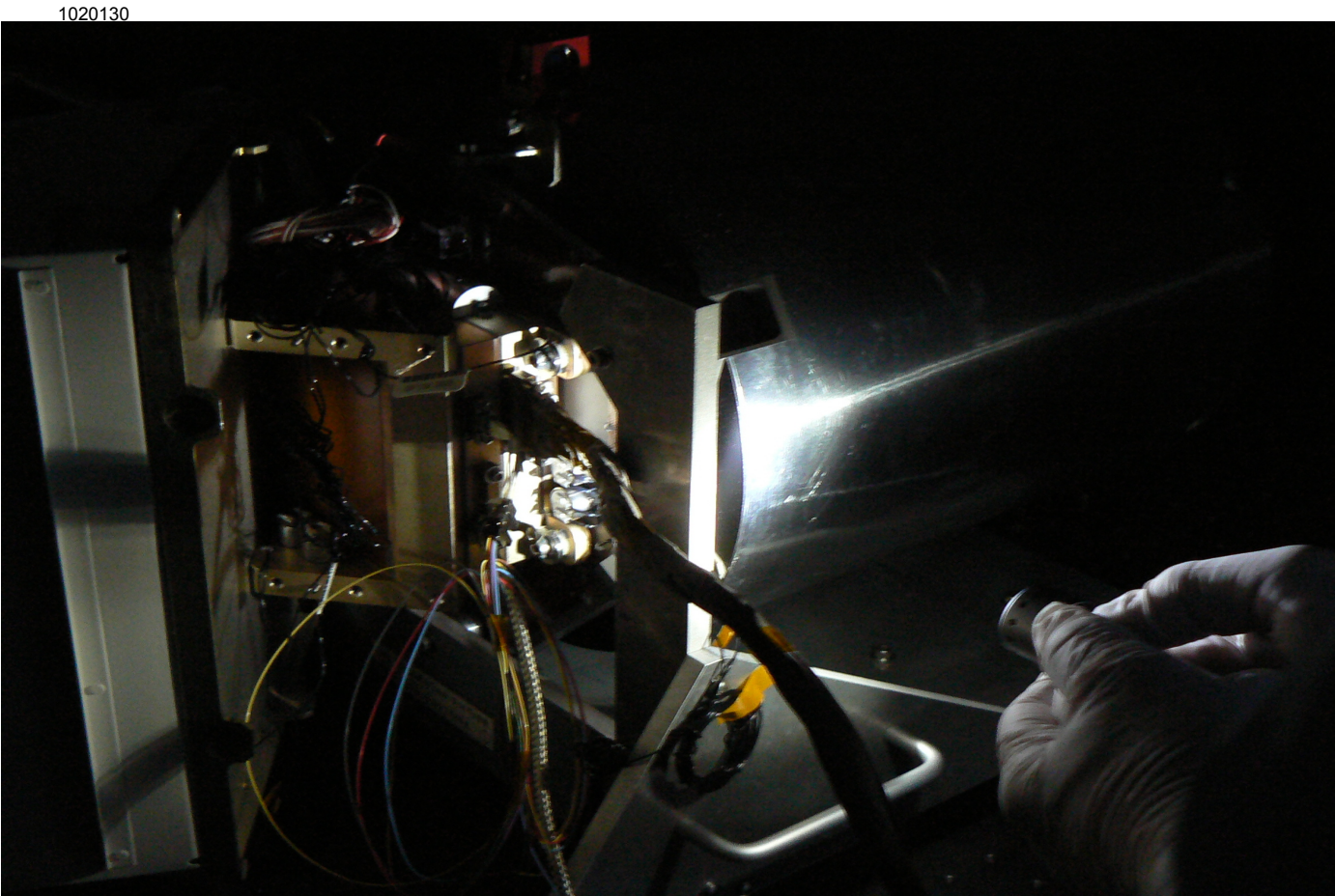
The flat fields will change slightly from the ones posted on the Web site when the flight pipeline is completed.

Note:

Some particles on the detector, unlike in February. Probably, they came from all the processing of NAC1.

There are 8 particles absorbing 4-8% of the signal. These will move on launch, of course, but I think we can take them out with the flight flat field.

NACFU1 light leak calibration with white LED flashlight



Data were taken 2/10/2008.

We shone the beam of a white LED flashlight onto various spots on the outside of the NAC, with the room dark and the NAC shuttered. No leaked light was observed.

Snapshots are available as numbered files at <http://roc.sese.asu.edu/WORK/CALB/NAC1/PICS/20080210.html>

Calibration parameters			NAC parameters						
Filename	Dark	Snapshot numb	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)
N13IFa0.ddd	Flashlight off	1020129		0	Lin1	200	14	61	4095
N13IFa1.ddd		1020130		0	Lin1	200	14	61	4095
N13IFa2.ddd		1020131		0	Lin1	200	14	61	4095

light_leak

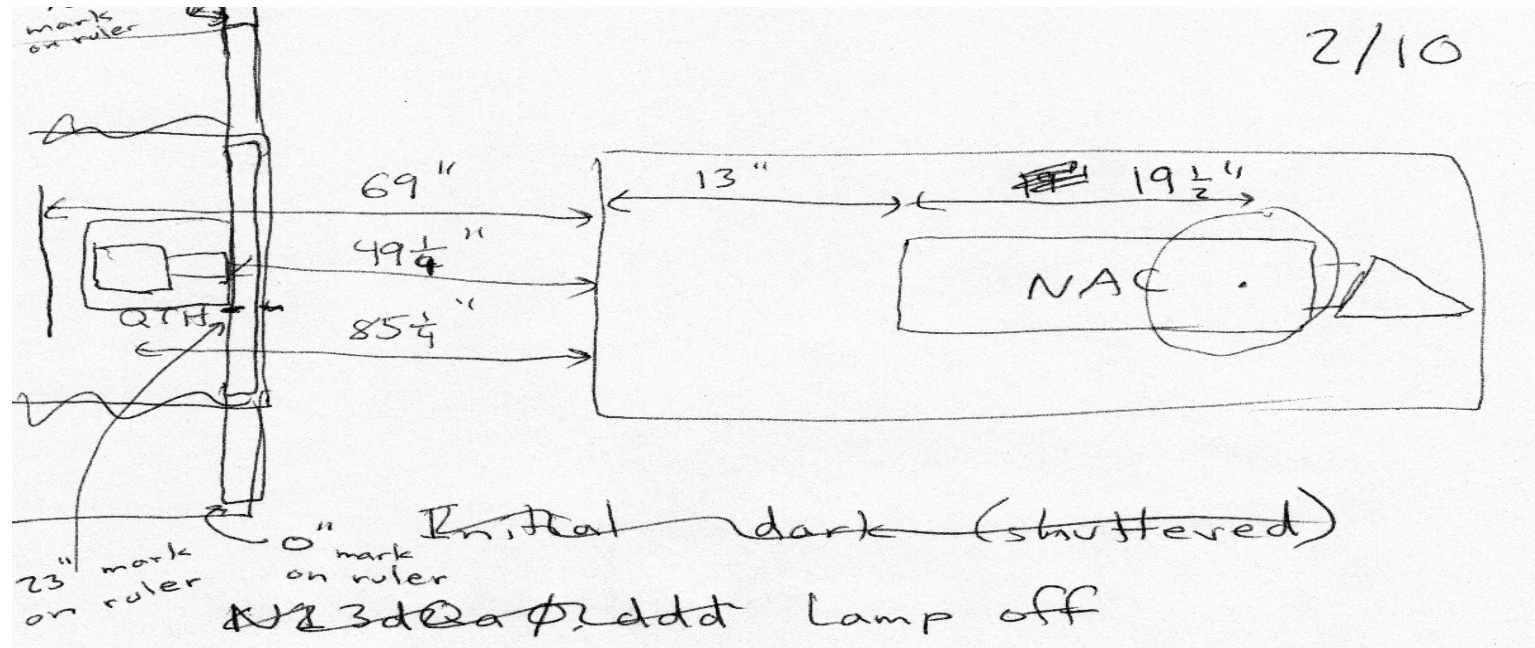
N13IFa3.ddd	1020132	0 Lin1	200	14	61	4095	35.246
N13IFa4.ddd	1020133	0 Lin1	200	14	61	4095	35.246
N13IFa5.ddd	1020134	0 Lin1	200	14	61	4095	35.246
N13IFa6.ddd	1020135	0 Lin1	200	14	61	4095	35.246
N13IFa7.ddd	1020136	0 Lin1	200	14	61	4095	35.246
N13IFa8.ddd	1020137	0 Lin1	200	14	61	4095	35.246
N13IFa9.ddd	1020138	0 Lin1	200	14	61	4095	35.246
N13IFa10.ddd	1020139	0 Lin1	200	14	61	4095	35.246
N13IFa11.ddd	1020140	0 Lin1	200	14	61	4095	35.246
N13IFa12.ddd	1020141	0 Lin1	200	14	61	4095	35.246
N13IFa13.ddd	1020142	0 Lin1	200	14	61	4095	35.246
N13IFa14.ddd	1020143	0 Lin1	200	14	61	4095	35.246
N13IFa15.ddd	1020144	0 Lin1	200	14	61	4095	35.246
N13IFa16.ddd	1020145	0 Lin1	200	14	61	4095	35.246
N13IFa17.ddd	1020146	0 Lin1	200	14	61	4095	35.246
N13IFa18.ddd	1020147	0 Lin1	200	14	61	4095	35.246
N13IFa19.ddd Flashlight off	1020148	0 Lin1	200	14	61	4095	35.246

Analysis available as of 6/27/2008

No written report but briefly mentioned at <http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080210-1-straylight/index.html>

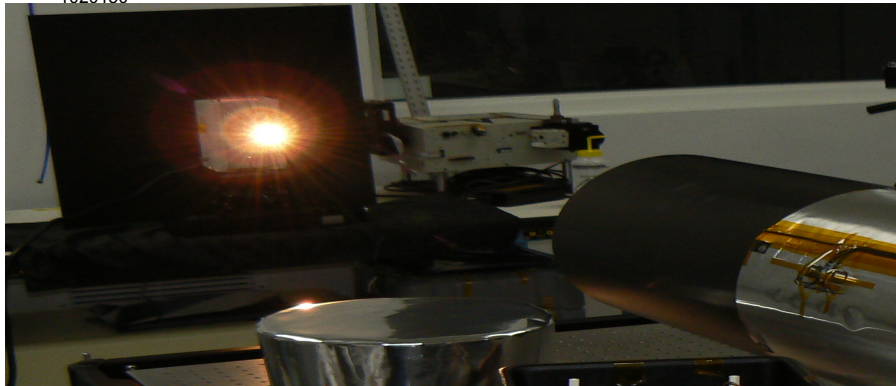
Mark Robinson looked at these images carefully and was not able to discover any light leaks.

NACFU1 stray light calibration with QTH lamp

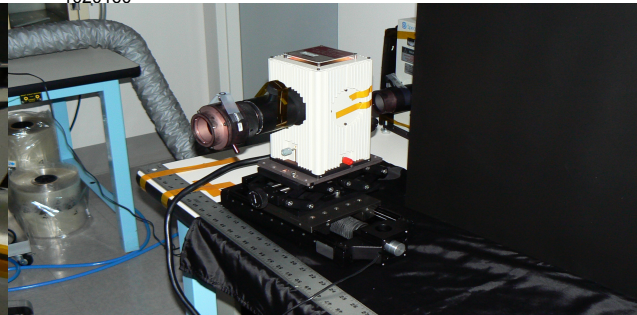


Data were taken 2/10/2008.

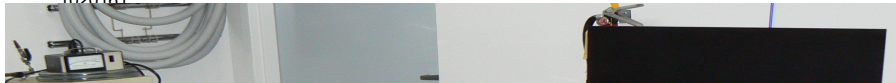
1020150



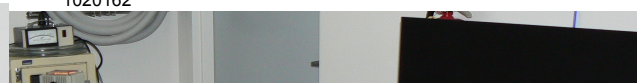
1020160



1020161



1020162





The QTH lamp is not well characterized geometrically, except that it is compact. It is out of focus, of course. Because it is compact, it can generate some stray light features much stronger than they would appear in a flat field or flight image. Images were taken with the lamp shining straight down into the telescope (both obscured and unobscured by the secondary mirror). However, because of the uncontrolled geometry, one can't just divide by those images to get the flight stray light as a fraction of the scene. In particular, the ghosts seen around columns 1000 and 4000 are much stronger in some of these images than they are for a flat field or in flight.

When we change the exposure time parameter from the minimum value of 0 to the maximum value of 4095, the exposure time in ms changes by about a factor of 100. By changing integration time, we can make the measurement more sensitive. This allows stray light to be measured better at large angles. We can also change between the lin16 and the lin1 companding tables. That gives a factor of 16.

The QTH lamp current is 7.8 amperes for all these data.

Calibration parameters					NAC parameters							
Filename	Dark	Lamp crosstrack	Snapshot numb	Notes	Mode	Companding table	DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N13sQa1.ddd		23	102150		0	Lin16		200	14	61	0	0.337
N13sQa2.ddd		20			0	Lin16		200	14	61	0	0.337
N13sQa3.ddd		18			0	Lin16		200	14	61	0	0.337

stray_qth

N13sQa4.ddd	17	0 Lin16	200	14	61	0	0.337
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...insert additional filenames and data, starting with page 5 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210a-CalLog.pdf>
 ...and continued starting with page 1 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210to11-CalLog.pdf>

N13sQe10.ddd	44	0 Lin1	200	14	61	4095	35.246
N13sQe11.ddd	46	0 Lin1	200	14	61	4095	35.246
N13dQg0.ddd	Shuttered, lamp off	0 Lin1	200	14	61	4095	35.246
N13sQf1.ddd	100.5	0 Lin1	200	14	61	4095	35.246
N13sQf2.ddd	60 degrees 1020163	0 Lin1	200	14	61	0	0.337
N13sQf2.ddd	I believe shuttered, lamp off, but the notes don't say it	0 Lin1	200	14	61	320	3.065
N13sQf2.ddd	I believe shuttered, lamp off, but the notes don't say it	0 Lin1	200	14	61	4095	35.246

Analysis available as of 6/27/2008

No reports; the link would be <http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080210-1-straylight/index.html>

Some comments (Dave Humm):

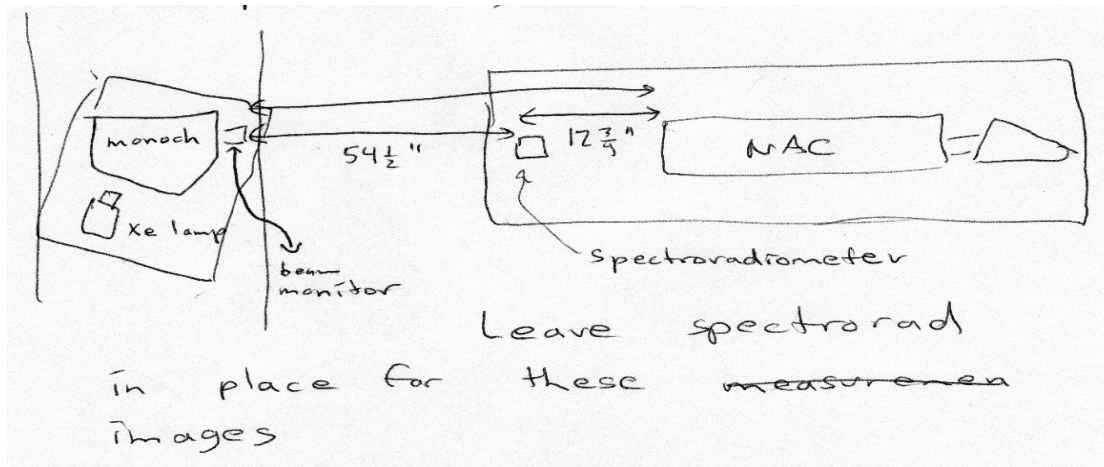
1. The ghost near columns 1000 and 4000 is visible but much stronger than in flight; it's appropriately measured in the flat fields with the black plate taken in

April; see <http://roc.sese.asu.edu/WORK/CALB/NAC1/straylight/index.html>.

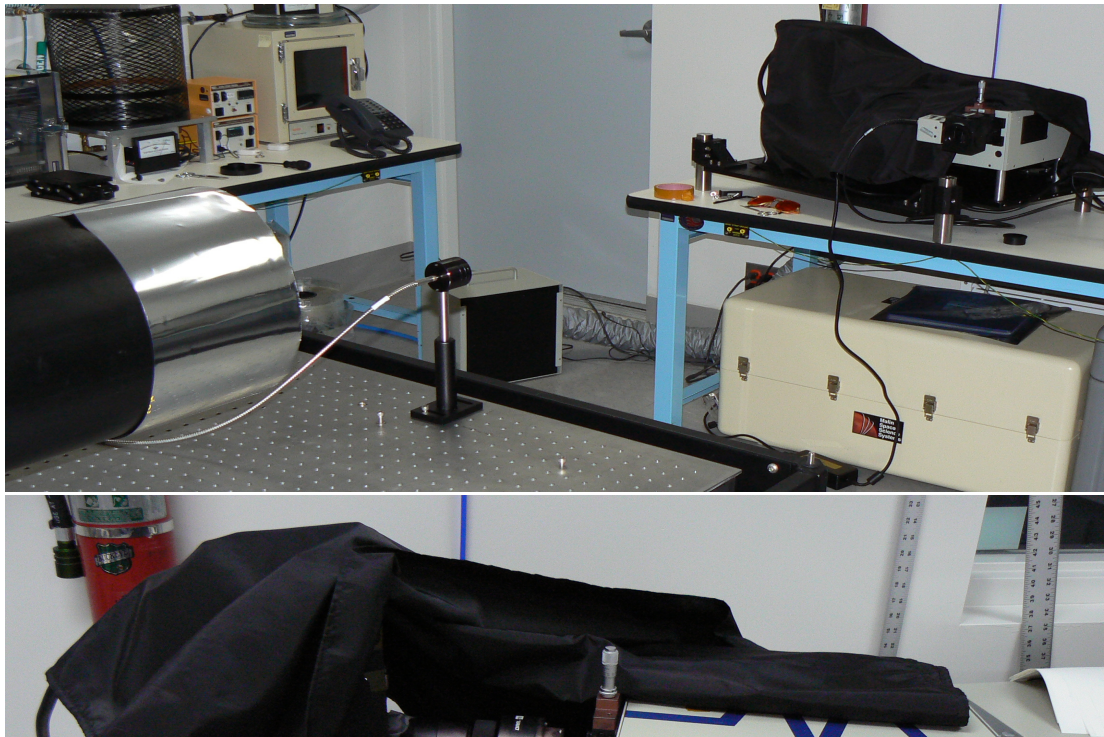
2. A cursory look at the images indicates no other significant stray light features, but there hasn't been an in-depth analysis.

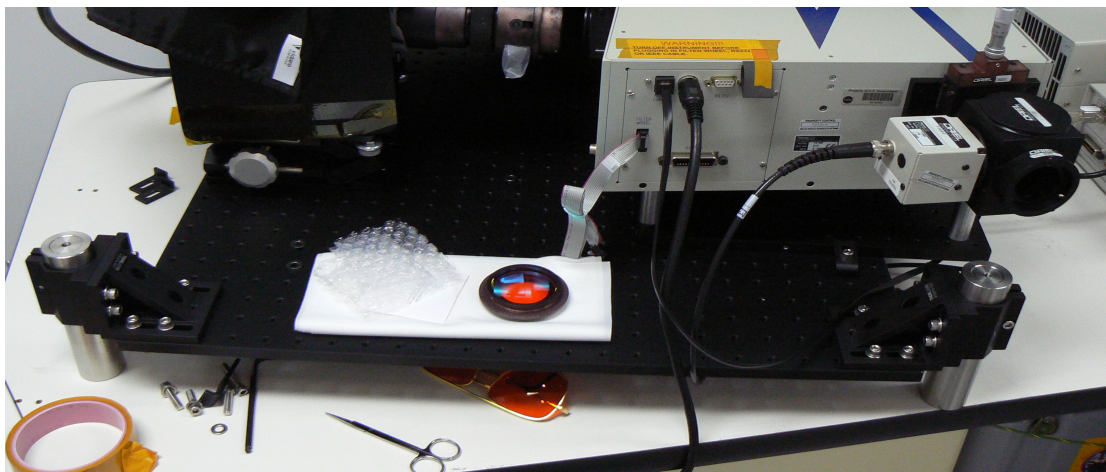
3. The image with the QTH lamp centered on the optical axis (and therefore blocked by the secondary mirror) shows a small bump at the center of the field which I believe is Poisson's spot! If this is correct, it will not be a significant effect in flight.

NACFU1 responsivity as a function of wavelength



Data were taken 2/11/2008.





The exit slit of the monochromator is not well characterized geometrically, except that it is compact. It is out of focus, of course. It was off center so that it would not be blocked by the secondary mirror, and the cone of light filled most of the NAC aperture. We used the lens from the QTH along with the Xe lamp so that we could have the brightest possible light focused on the entrance slit of the monochromator.

These data were taken with both the entrance and exit slits of the monochromator both set to 3 mm unless otherwise noted. When the entrance slit of the monochromator was increased from 1 mm to 3mm at 600 nm, the beam monitor reading increased by a factor of only 5/3 rather than the expected factor of 3, indicating that the effective entrance slit is determined by the lamp as well as the actual entrance slit. This could in theory affect the wavelength produced by the monochromator, but only by a fraction of a nm for this setup, which is insignificant. This is a ¼ meter Czerny-Turner monochromator with a 3-grating turret; details at [http://roc.sese.asu.edu/WORK/CALB/NAC1/SD/e5385 Oriol-Cornerstone-260-14-m-Monochromator.pdf](http://roc.sese.asu.edu/WORK/CALB/NAC1/SD/e5385%20Oriol-Cornerstone-260-14-m-Monochromator.pdf). The beam monitor is a calibrated silicon photodiode; details of power meter at <http://roc.sese.asu.edu/WORK/CALB/NAC1/SD/70310.pdf>. Note the beam monitor gives power up to a constant factor, and it's equivalent to radiance as a function of wavelength up to a constant factor. The beam monitor is believed to be accurate across the entire spectral range. According to spectroradiometer measurements of the calibrated integrating sphere, the spectroradiometer is accurate 400-700 nm, **except** it overstates the spectral radiance by a factor of 2.4, which doesn't matter for the monochromator measurement. The monochromator measurement is geometrically uncontrolled and the spectroradiometer samples only a small part of the beam. Therefore the spectroradiometer measurements are accurate only up to a constant factor anyway. The monochromator was set to grating 2; I believe that is 1200 lines/mm but I have not verified it (D. Humm 7/21/2008). For wavelengths 700-1100 nm, a longpass order-sorting filter was inserted before the entrance slit of the monochromator. The filter is Andover 600FH90-50 AM-67408 S/N 03. For wavelengths 400-700 nm, there is no filter. At 700 nm, we took data both with and without the order-sorting filter.

Calibration parameters						NAC parameters						
Filename	Dark	Wavelength (nm)	Beam monitor (Ultralex stage)	Order sorting filter	Notes	Mode	Companding	tai DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)
Spectroradiometer Monochromator		600										
Spectroradiometer scan sm14tx		600			Entrance slit 1 mm, exit slit 1 mm							
Spectroradiometer scan sm14tx		600			Entrance slit 1 mm, exit slit 1 mm							
Spectroradiometer scan sm14tx		600	0.83		Entrance slit 3 mm, exit slit 1 mm							
Spectroradiometer scan sm14tx		600	1.531		Entrance slit 1 mm, exit slit 3 mm							
Spectroradiometer Monochromator		600			Entrance slit 1 mm, exit slit 3 mm							
Spectroradiometer scan sm14tx		600			Entrance slit 1 mm, exit slit 3 mm							
Spectroradiometer scan sm14tx		600	1.528		Entrance slit 1 mm, exit slit 3 mm							
Spectroradiometer scan sm14tx		600	2.516		Entrance slit 3 mm, exit slit 3 mm							
Spectroradiometer scan sm14m		350	2.795									
Spectroradiometer scan sm14m		360	3.007									

...insert additional spectroradiometer scan filenames and data, starting with page 11 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210to11-CaliLog.pdf>

Spectroradiometer scan sm14m	1080	0.413	In
Spectroradiometer scan sm14m	1090	0.2759	In
Spectroradiometer scan sm14m	1100		In

N14mX0.ddd	350	2.653	0	0 Lin1	200	14	61	4095	35.246
N14mX1.ddd	350	2.653	0	10	200	14	61	4095	35.246
N14mX2.ddd	350	2.653	0	30	200	14	61	4095	35.246
N14mX3.ddd	360	2.864	0	0 Lin1	200	14	61	4095	35.246
N14mX4.ddd	360	2.864	0	10	200	14	61	4095	35.246
N14mX5.ddd	360	2.864	0	30	200	14	61	4095	35.246

...insert additional filenames and data, starting with page 18 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210to11-CalLog.pdf>

N14mX157.ddd	1050	0.4073	0 In	0 Lin1	200	14	61	4095	35.246
N14mX158.ddd	1060	0.2617	0 In	0 Lin1	200	14	61	4095	35.246
N14mX159.ddd	1070	0.2518	0 In	0 Lin1	200	14	61	4095	35.246
N14mX160.ddd	1080	0.4135	0 In	0 Lin1	200	14	61	4095	35.246
N14mX161.ddd	1090	0.2765	0 In	0 Lin1	200	14	61	4095	35.246
N14mX162.ddd	1100	0.1738	0 In	0 Lin1	200	14	61	4095	35.246
N14dXd0.ddd	Monochromator shuttered; NAC shuttered			0 Lin1	200	14	61	4095	35.246
N14dXd1.ddd	Monochromator shuttered; NAC shuttered			0 Lin16	200	14	61	4095	35.246
N14dXd2.ddd	Monochromator shuttered; NAC shuttered			10	200	14	61	4095	35.246
N14dXd3.ddd	Monochromator shuttered; NAC shuttered			30	200	14	61	4095	35.246
N14mXa0.ddd	350	2.794	1	0 Lin1	200	14	61	4095	35.246
N14mXa1.ddd	400	3.627	1	0 Lin16	200	14	61	4095	35.246

...insert additional filenames and data, starting with page 25 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210to11-CalLog.pdf>

N14mXa14.ddd	1050	0.4083	1 In	0 Lin1	200	14	61	4095	35.246
N14mXa15.ddd	1100	0.1742	1 In	0 Lin1	200	14	61	4095	35.246
N14mXb0.ddd	350	2.794	-1	0 Lin1	200	14	61	4095	35.246
N14mXb1.ddd	400	3.627	-1	0 Lin16	200	14	61	4095	35.246

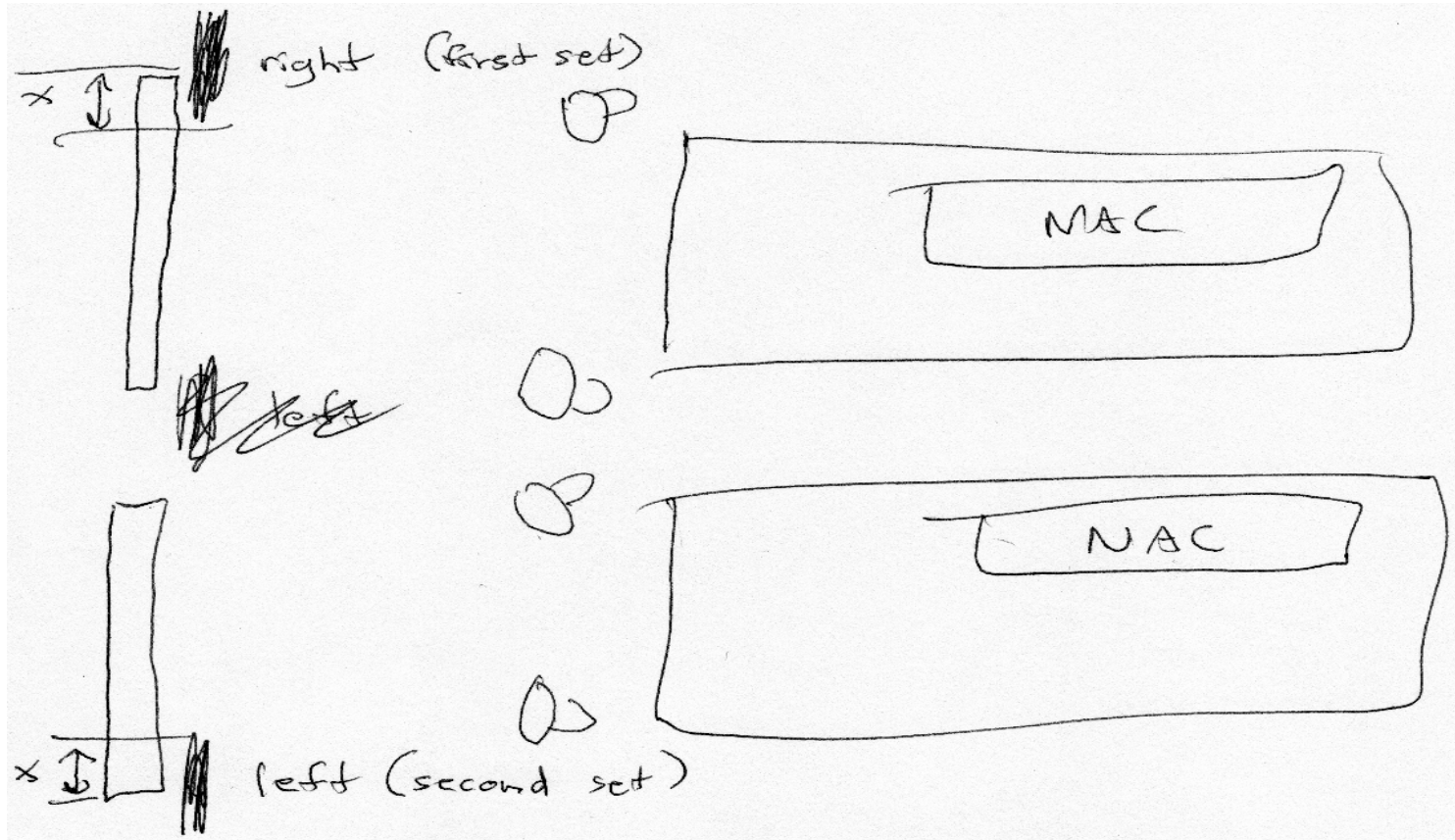
...insert additional filenames and data, starting with page 26 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC1-20080210to11-CalLog.pdf>

N14mXb14.ddd	1050	0.4097	1 In	0 Lin1	200	14	61	4095	35.246
N14mXb15.ddd	1100	0.1746	1 In	0 Lin1	200	14	61	4095	35.246
N14dXe0.ddd	Monochromator shuttered; NAC shuttered			0 Lin1	200	14	61	0	0.337
N14dXe1.ddd	Monochromator shuttered; NAC shuttered			0 Lin1	200	14	61	320	3.065
N14dXe2.ddd	Monochromator shuttered; NAC shuttered			0 Lin1	200	14	61	4095	35.246
N14dXe3.ddd	Monochromator shuttered; NAC shuttered			0 Lin16	200	14	61	4095	35.246
N14dXe4.ddd	Monochromator shuttered; NAC shuttered			10	200	14	61	4095	35.246
N14dXe5.ddd	Monochromator shuttered; NAC shuttered			30	200	14	61	4095	35.246

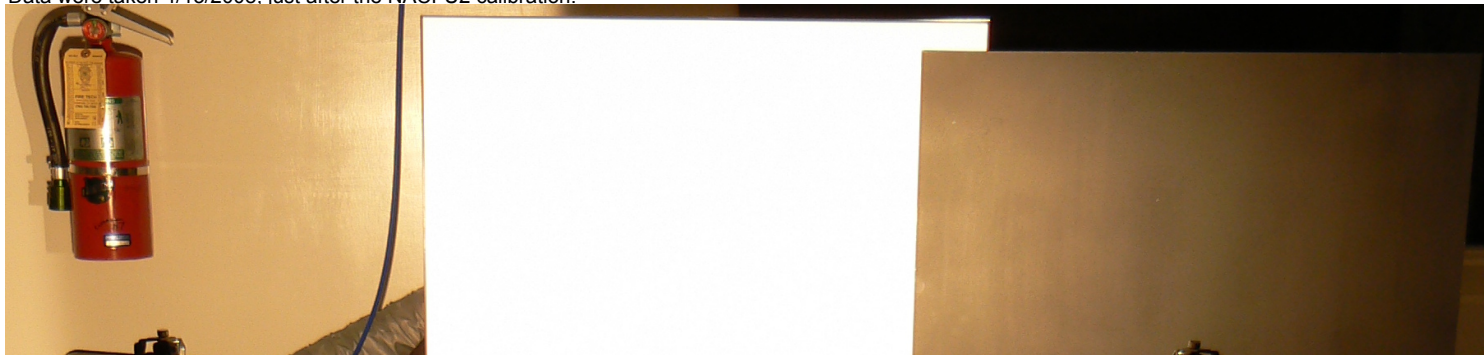
Analysis available as of 7/23/2008

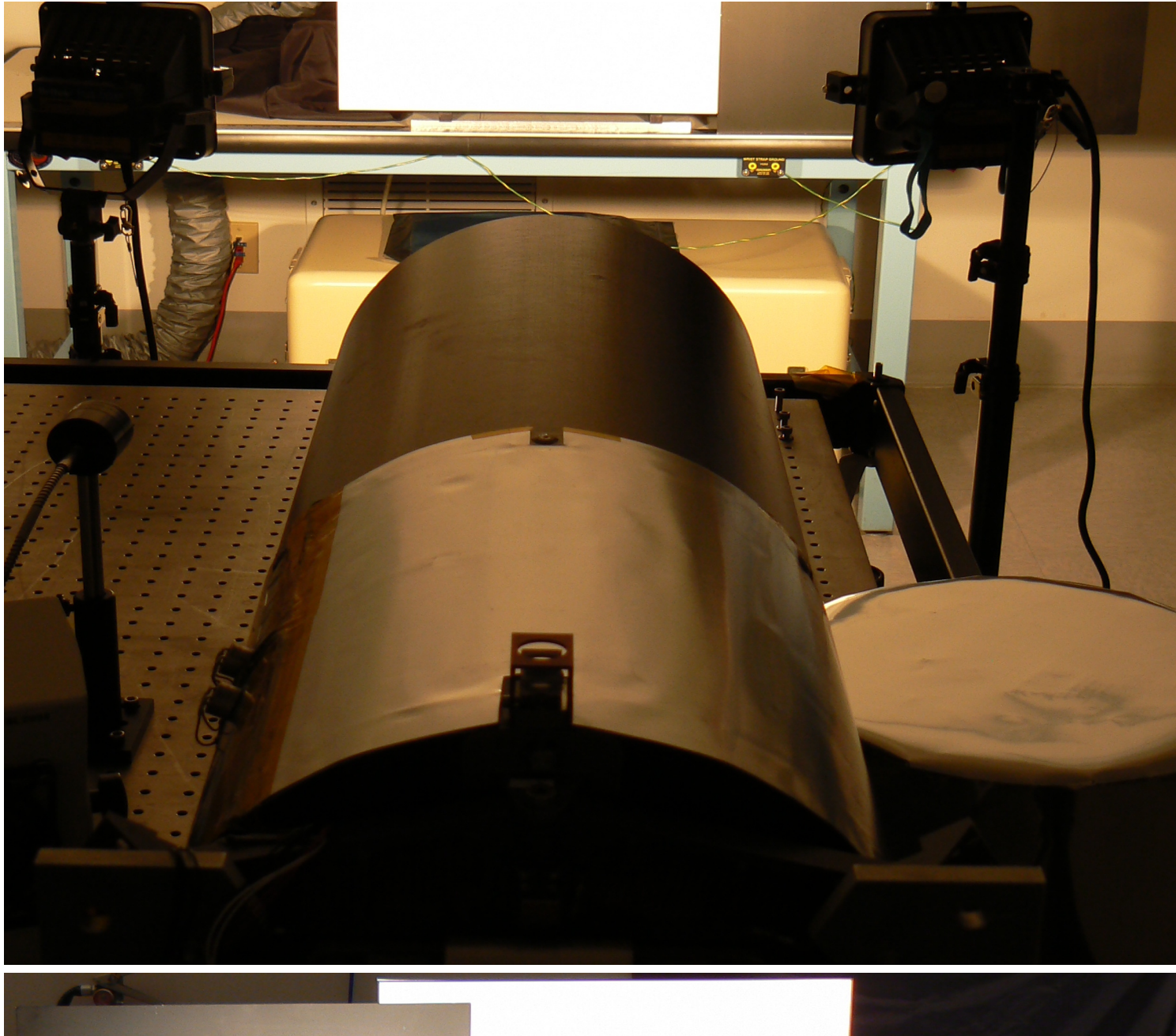
<http://roc.sese.asu.edu/WORK/CALB/NAC1/NAC1-080211-spectral/index.html>

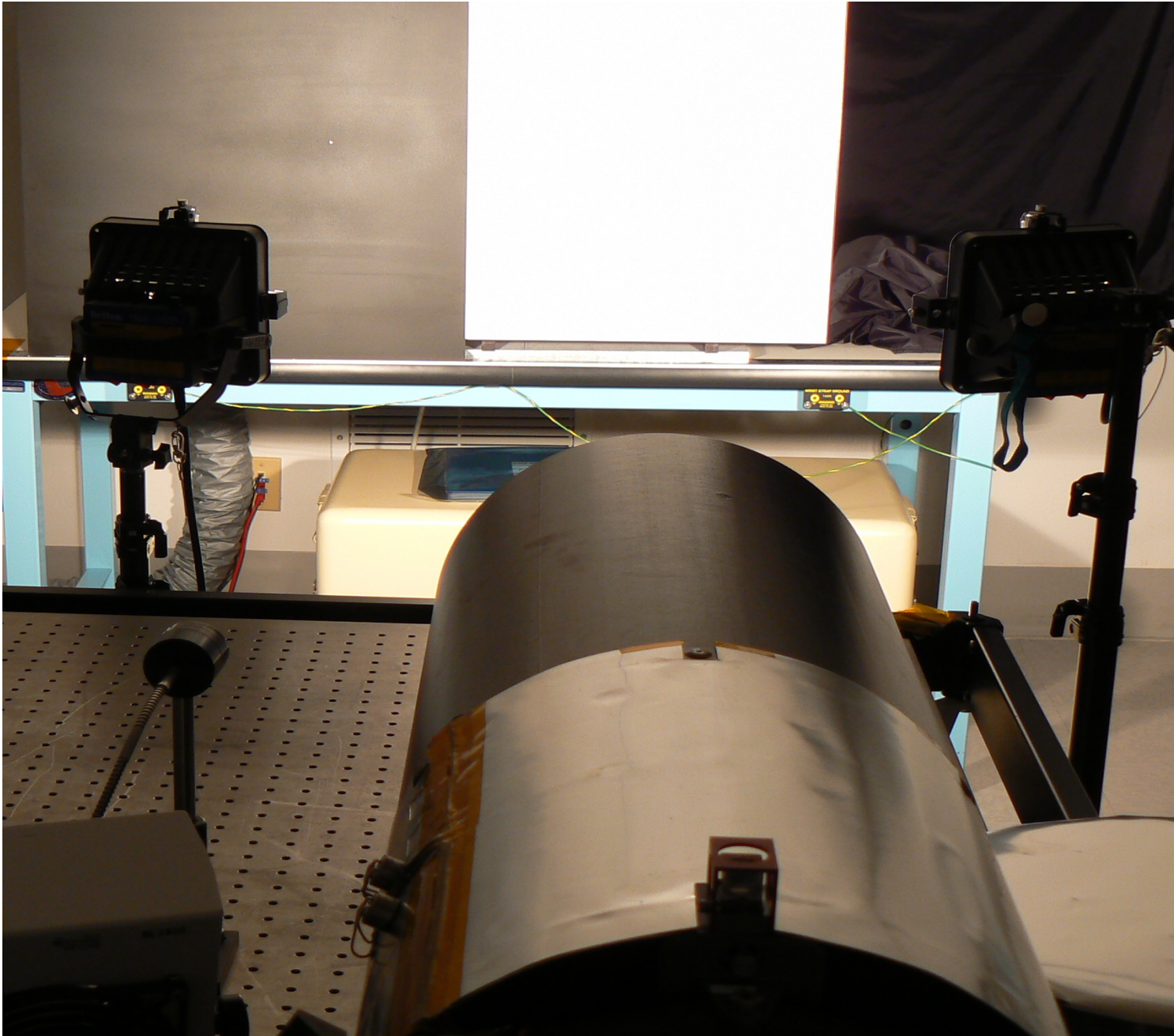
NACFU1 flat field with black plate obscuring the ghost on each side



Data were taken 4/13/2008, just after the NACFU2 calibration.









The sources of the ghosts centered at columns ~1000 and ~4000 are just outside the field of view.

The source of each ghost is on the same side of the field of view as that ghost.

Analysis indicated that the images with 5 inches of the white panel covered by the black plate blocks the source of the ghost on that side without Vignetting the signal inside the field of view at all.

The ratio of the full white panel to the white panel with 5 inches covered by the black plate gives the ghost as a fraction of the signal.

The two photo flood lamps provide very bright and very uniform illumination of the Spectralon panel. The photo flood lamps are driven directly by AC wall current, and they suffer from 3 kinds of variability:

1. Variability of the AC wall current voltage amplitude over tens of minutes to hours, making the overall brightness nonrepeatable by a few percent.
2. The actual 120 Hz variation in lamp filament temperature due to the 120 Hz variation in electric power due to the 60 Hz variation in voltage. This gives rise to horizontal stripes in the images with an amplitude of about 3%.
3. The lamps are very hot and one sees heat waves rising from them. The lensing causes variability in one photo lamp with respect to another.

This leads to gradients of ~1% in the panel uniformity, varying with a timescale of a couple of tenths of a second.

This averages out to no gradient over many lines and many images.

For flat field calculations, the mode 10 and mode 30 data is particularly valuable because it has the full 12 bits of accuracy in DN. For darks, of course, mode 0, lin1 data is just as good because it gives fully accurate DN for DN<256. Bright images in mode 0, lin16 are not as accurate because the images are entirely multiples of 16 DN. This second set of flat field data has good images in mode 10 and mode 30, unlike the first set.

Spectroradiometer scans are taken to verify that the panel is flat and to monitor brightness changes with time.

The spectroradiometer is accurate 400-700 nm **except** one has to multiply the measured value by a factor of 2.4 to get an accurate value.

The spectroradiometer is **not** accurate >700 nm. We believe it is repeatable at all wavelengths, but this has not been carefully verified.

Calibration parameters			NAC parameters		Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
Filename	Dark	Notes	Mode	Companding tat DAC					
Spectroradiometer scan srn11fL									
N11sLa0.ddd		Full white screen, no black plate	0 Lin16		200	77	124	140	1.531
N11sLa1.ddd		Full white screen, no black plate	10		200			140	1.531
N11sLa2.ddd		Full white screen, no black plate	30		200			140	1.531
Spectroradiometer scan srn11fL									
N11sLa3.ddd		Black plate covers 3" on right side	0 Lin16		200	77	124	140	1.531
N11sLa4.ddd		Black plate covers 3" on right sic	10		200			140	1.531
N11sLa5.ddd		Black plate covers 3" on right sic	30		200			140	1.531
Spectroradiometer scan srn11fL									
N11sLa6.ddd		Black plate covers 4" on right side	0 Lin16		200	77	124	140	1.531
N11sLa7.ddd		Black plate covers 4" on right sic	10		200			140	1.531
N11sLa8.ddd		Black plate covers 4" on right sic	30		200			140	1.531

...insert additional filenames and data, starting with page 12 of lab notes <http://roc.sese.asu.edu/WORK/CALB/NAC1/PDF/NAC2&NAC1-20080413-CalLog.pdf>

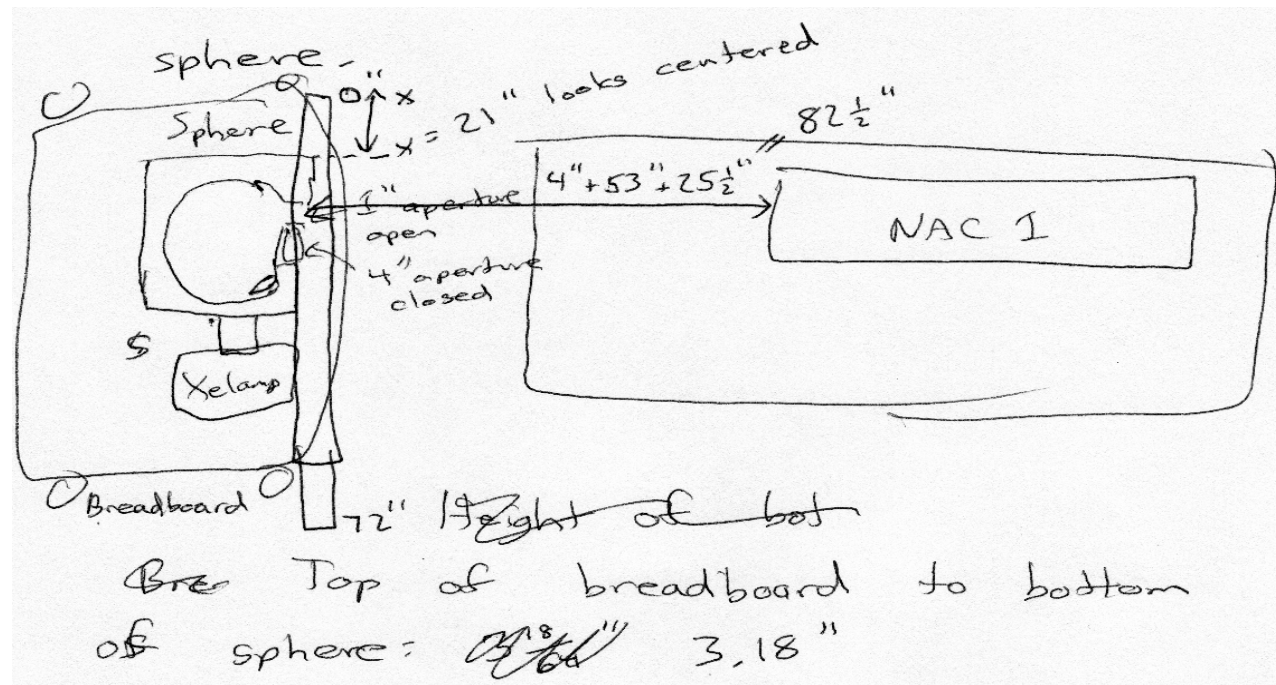
Spectroradiometer scan srn11fL Black plate covers 8" on left side							
N11sLa39.ddd	Black plate covers 8" on left side	0 Lin16	200	77	124	140	1.531
N11sLa40.ddd	Black plate covers 8" on left side	10	200			140	1.531
N11sLa41.ddd	Black plate covers 8" on left side	30	200			140	1.531
Spectroradiometer scan srn11fL Full white screen, no black plate							
N11dLf0.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	140	1.531
N11dLf1.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	140	1.531
N11dLf2.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	140	1.531
N11dLf3.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	140	1.531
N11dLf4.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	140	1.531
N11dLf5.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	0	0.337
N11dLf6.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	0	0.337
N11dLf7.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	0	0.337
N11dLf8.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	0	0.337
N11dLf9.ddd	Lamps off, room lights out, NAC shuttered	0 Lin1	200	77	124	0	0.337

Analysis available as of 7/23/2008

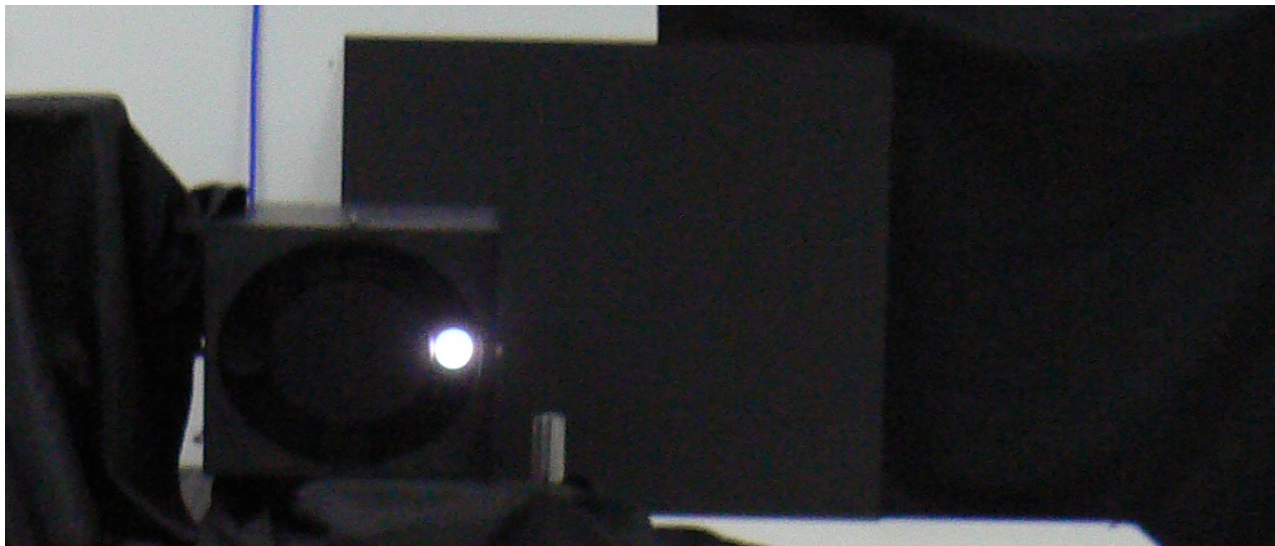
<http://roc.sese.asu.edu/WORK/CALB/NAC1/straylight/index.html>

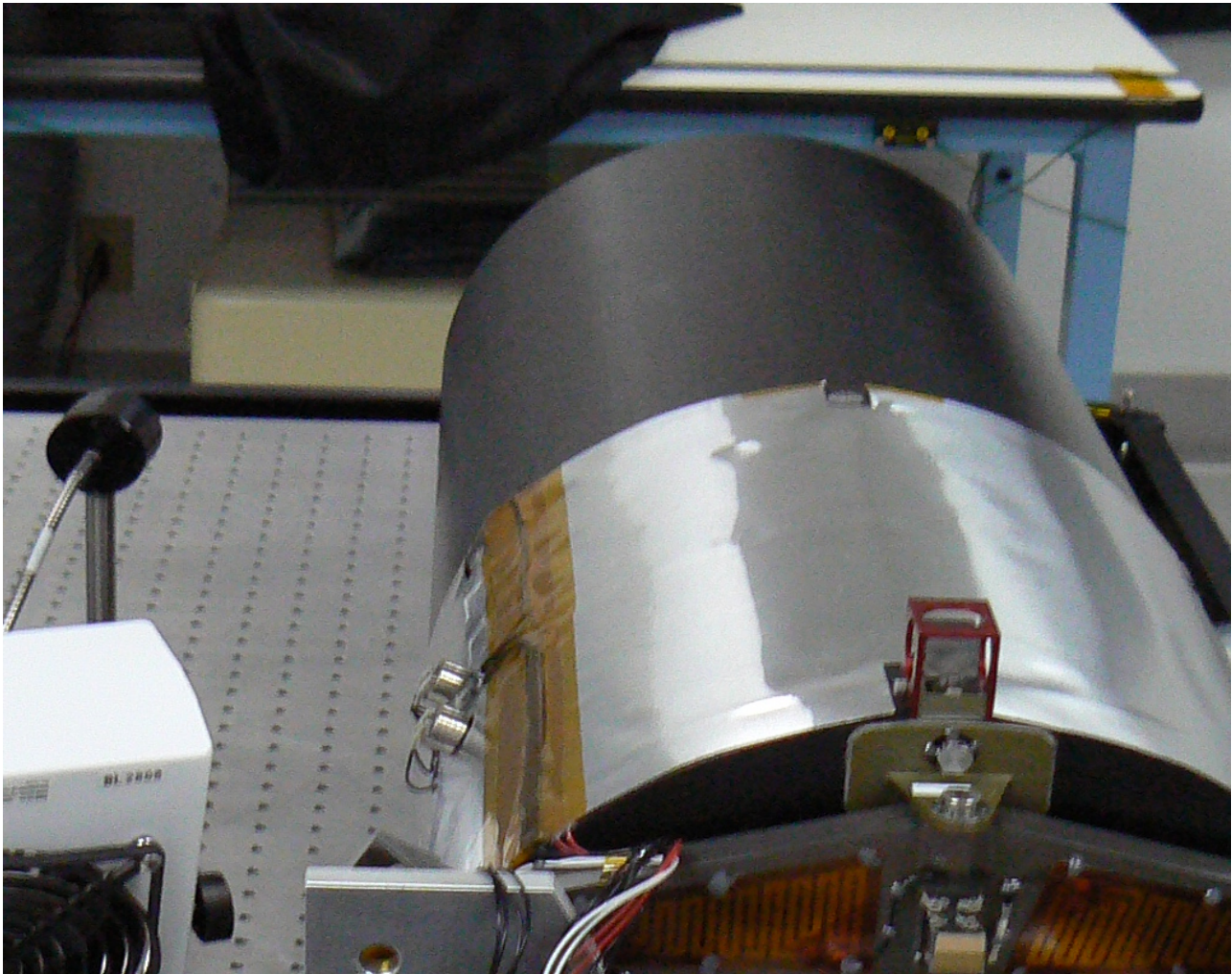
The last two plots on the page are taken from these data and the last plot gives the fraction of the ghost as a function of signal.

NACFU1 stray light calibration with sphere with 1 inch aperture and Xe lamp



Data were taken 4/13/2008.





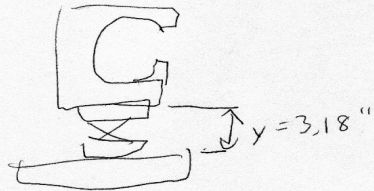
Sphere is moved from side to side and position is measured on a long metal ruler. 21 inches approximately centers the 1 inch aperture.

When we change the exposure time parameter from the minimum value of 0 to the maximum value of 4095, the exposure time in ms changes by about a factor of 100. By changing integration time, we can make the measurement more sensitive. This allows stray light to be measured better at large angles. We can also change between the lin16 and the lin1 companding tables. That gives a factor of 16.

Calibration parameters					NAC parameters						
Filename	Dark	Sphere crosstra	Sphere height	Notes	Mode	Companding tal DAC	Dc offset A	Dc offset B	Exp command	Exposure time (ms)	
N13sXc0.ddd		28	3.18		0	Lin1	200	40	87	4095	35.246
N13sXc1.ddd		28.5	3.18		0	Lin1	200	40	87	4095	35.246

N13sXc2.ddd	28.5	3.18	0 Lin16	200	40	87	4095	35.246
N13sXc3.ddd	29	3.18	0 Lin16	200	40	87	4095	35.246
N13sXc4.ddd	29.5	3.18	0 Lin16	200	40	87	4095	35.246
N13sXc5.ddd	29.5	3.18	0 Lin1	200	40	87	4095	35.246
N13sXc6.ddd	30	3.18	0 Lin1	200	40	87	4095	35.246
N13sXc7.ddd	30.5	3.18	0 Lin1	200	40	87	4095	35.246
N13sXc8.ddd	29	3.18	0 Lin1	200	40	87	4095	35.246
N13sXc9.ddd	29	3.18	0 Lin16	200	40	87	4095	35.246

Above have $y = 3.18''$



Change y to peak up ghost-

N13sXc10.ddd	29	3.18	0 Lin16	200	40	87	4095	35.246
N13sXc11.ddd	29	3.18	0 Lin1	200	40	87	4095	35.246
N13sXc12.ddd	29	3.7	0 Lin16	200	40	87	4095	35.246
N13sXc13.ddd	29	4.2	0 Lin16	200	40	87	4095	35.246
N13sXd0.ddd	29	3.7	0 Lin16	200	40	87	4095	35.246
N13sXe0.ddd	29	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe1.ddd	30.5	3.49	0 Lin1	200	40	87	4095	35.246
N13sXe2.ddd	30	3.49	0 Lin1	200	40	87	4095	35.246
N13sXe3.ddd	29.5	3.49	0 Lin1	200	40	87	4095	35.246
N13sXe4.ddd	29.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe5.ddd	28.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe6.ddd	28	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe7.ddd	27.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe8.ddd	21.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe9.ddd	15.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe10.ddd	15	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe11.ddd	14.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe12.ddd	14	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe13.ddd	13.5	3.49	0 Lin16	200	40	87	4095	35.246
N13sXe14.ddd	13.5	3.49	0 Lin1	200	40	87	4095	35.246
N13sXe15.ddd	13	3.49	0 Lin1	200	40	87	4095	35.246
N13sXe16.ddd	12.5	3.49	0 Lin1	200	40	87	4095	35.246
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	4095	35.246
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	3200	27.617
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	0	0.337
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	400	3.747
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	800	7.157
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	50	0.764
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	1800	15.682
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	100	1.19
N13dXa0.ddd	Lamps off, NAC shuttered		0 Lin1	200	40	87	4095	35.246

stray_sphere

N13dXa0.ddd	Lamps off, NAC shuttered	0 Lin1	200	40	87	200	2.042
N13dXa0.ddd	Lamps off, NAC shuttered	0 Lin1	200	40	87	3600	31.027
N13dXa0.ddd	Lamps off, NAC shuttered	0 Lin1	200	40	87	1200	10.567
N13dXa0.ddd	Lamps off, NAC shuttered	0 Lin1	200	40	87	2400	20.797
N13dXa0.ddd	Lamps off, NAC shuttered	0 Lin1	200	40	87	0	0.337

Analysis available as of 7/23/2008

<http://lroc.sese.asu.edu/WORK/CALB/NAC1/straylight/index.html>

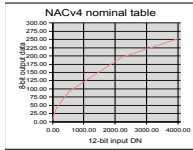
The first plot on the page is taken from this data set, and just shows the existence of the ghost.

A qualitative look at these images did not indicate any other significant stray light feature.

As of 7/23/2008, there has not been a detailed quantitative analysis.

NAC LUTs
 maxDN 4095 (12-bit)
 Use linear segments with inverse slopes 1, 2, 4, 8, 16, and 32
 truly full well 300K e⁻ NAC
 For 2x2 pixel binning, choose table assuming twice the DN of full-resolution mode for the same scene
 (twice integration time and two crosscorr ovals are summed, but crosscorrelation acts on 12 highest bits of 13-bit sum, effectively dividing by 2)
 Lunar DN values for full-resolution based on MoonExo.23 320nm 30wide.pdf by Mike Ravine, et al

read noise 100
 gain 75
 Offset (12-bit) 8



Uses 5 slopes and covers 0-4095; this is Mike Caslinger's engineering model table; good for general use?
 Nominal; e⁻ < 40000 (avg highlands at 30 degrees incidence) has Nq <= 1.3 * Ne (quantiz <= 4.3 * noise)
 e signal noise e SNR 12-bit DN Noise eq C(DN14) DN8 Quantiz RSS N No/Ne / SNR SNR% Slope Intercept

e signal	noise e	SNR	12-bit DN	Noise eq C(DN14)	DN8	Quantiz	RSS N	No/Ne / SNR	SNR%	Slope	Intercept
0.00	100.00	0.00	8.00	1.33	2.00	4.00	0.60	1.46	0.45	0.00	
2362.50	111.19	21.25	31.50	1.48	4.00	15.75	0.60	1.60	0.40	14.69	0.692
2362.50	111.19	21.25	31.50	1.48	4.00	15.75	1.20	1.91	0.81	12.32	0.580
10162.50	141.99	71.57	135.50	1.89	4.00	41.75	1.20	2.24	0.63	56.88	0.795
10162.50	141.99	71.57	135.50	1.89	8.00	41.75	2.40	3.06	1.27	41.71	0.583
40162.50	223.97	179.32	535.50	2.99	8.00	91.75	2.40	3.83	0.80	137.69	0.768
40162.50	223.97	179.32	535.50	2.99	16.00	91.75	4.80	5.65	1.61	93.31	0.520
164962.50	418.29	394.38	2199.50	5.58	16.00	195.75	4.80	7.36	0.86	297.83	0.755
164962.50	418.29	394.38	2199.50	5.58	32.00	195.75	9.60	11.10	1.72	197.39	0.501
307125.00	563.14	545.38	4095.00	7.51	32.00	254.98	9.60	12.19	1.28	335.34	0.615
										0.03125	127.0

Item1 0
 Item2 8
 Item3 25
 Item4 59
 Item5 128
 Item6 128
 Item7 1
 Item8 136
 Item9 536
 Item10 2200
 Item11 32

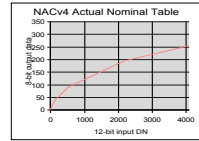
16-bit word Opcode Term select Pad Value

16-bit word	Opcode	Term select	Pad	Value
16896	2	1	0	0
17416	2	2	0	8
17845	2	3	0	25
18481	2	4	0	59
19072	2	5	0	128
28672	7	0	0	0
29168	7	1	4	535
29713	7	2	17	536
30275	7	3	87	2199
30695	7	4	275	2200
				196
				4095
				255

Actual inputs and outputs

12-bit DN 8-bit data

12-bit DN	8-bit data
0	0
31	15
32	16
135	41
136	42
535	91
536	92
2199	196
2200	196
4095	255



Uses 5 slopes and covers 0-4095; optimized for DN<500
 Dark; e⁻ < 40000 (avg highlands at 30 degrees incidence) has Nq <= 0.9 * Ne (quantiz <= 3 * noise)
 Nominal; e⁻ < 40000 (avg highlands at 30 degrees incidence) has Nq <= 1.3 * Ne (quantiz <= 4.3 * noise)
 e signal noise e SNR 12-bit DN Noise eq C(DN14) DN8 Quantiz RSS N No/Ne / SNR SNR% Slope Intercept

e signal	noise e	SNR	12-bit DN	Noise eq C(DN14)	DN8	Quantiz	RSS N	No/Ne / SNR	SNR%	Slope	Intercept
0.00	100.00	0.00	8.00	1.33	2.00	4.00	0.60	1.46	0.45	0.00	
4762.50	121.50	39.20	63.50	1.62	2.00	31.75	0.60	1.73	0.37	32.13	0.820
4762.50	121.50	39.20	63.50	1.62	4.00	31.75	1.20	2.02	0.74	27.53	0.702
31762.50	204.36	155.43	423.50	2.72	4.00	121.75	1.20	2.98	0.44	139.55	0.898
31762.50	204.36	155.43	423.50	2.72	8.00	121.75	2.40	3.63	0.88	114.43	0.736
40162.50	223.97	179.32	535.50	2.99	8.00	135.75	2.40	3.83	0.80	137.69	0.768
40162.50	223.97	179.32	535.50	2.99	16.00	135.75	4.80	5.65	1.61	93.31	0.520
59962.50	264.50	226.70	799.50	3.53	16.00	152.25	4.80	5.96	1.36	132.88	0.586
59962.50	264.50	226.70	799.50	3.53	32.00	152.25	9.60	10.23	2.72	77.39	0.341
307125.00	563.14	545.38	4095.00	7.51	32.00	255.23	9.60	12.19	1.28	335.34	0.615
										0.03125	127.3

Item1 0
 Item2 16
 Item3 69
 Item4 103
 Item5 128
 Item6 128
 Item7 1
 Item8 64
 Item9 536
 Item10 800
 Item11 32

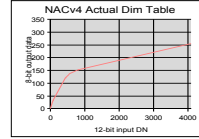
16-bit word Opcode Term select Pad Value

16-bit word	Opcode	Term select	Pad	Value
16896	2	1	0	0
17424	2	2	0	16
17869	2	3	0	69
18355	2	4	0	103
19072	2	5	0	128
28672	7	0	0	0
29168	7	1	8	535
29713	7	2	53	536
30275	7	3	87	799
30695	7	4	100	800
				4095
				255

Actual inputs and outputs

12-bit DN 8-bit data

12-bit DN	8-bit data
0	0
16	0
63	31
64	32
423	121
424	122
535	135
536	136
799	152
800	153
4095	255



Uses 3 slopes and covers 0-4095; optimized for 500<DN<2000
 Bright; 40000 < e⁻ < 150000 (avg highlands at 30 degrees incidence) has Nq <= 0.9 * Ne (quantiz <= 4 * noise)
 Nominal; e⁻ < 150000 (bright highlands at 5 degrees incidence) has Nq <= 1.35 * Ne (quantiz <= 4.5 * noise)
 e signal noise e SNR 12-bit DN Noise eq C(DN14) DN8 Quantiz RSS N No/Ne / SNR SNR% Slope Intercept

e signal	noise e	SNR	12-bit DN	Noise eq C(DN14)	DN8	Quantiz	RSS N	No/Ne / SNR	SNR%	Slope	Intercept
0.00	100.00	0.00	8.00	1.33	8.00	1.00	2.40	2.75	1.80	0.00	
600.00	102.96	5.83	8.00	1.37	8.00	1.00	2.40	2.76	1.75	0.00	0.000
600.00	102.96	5.83	8.00	1.37	8.00	1.00	2.40	2.76	1.75	0.00	0.000
600.00	102.96	5.83	8.00	1.37	8.00	1.00	2.40	2.76	1.75	0.00	0.000
37462.50	217.86	171.96	499.50	2.90	8.00	62.44	2.40	3.77	0.83	130.44	0.759
77962.50	296.58	262.87	1039.50	3.95	8.00	129.94	2.40	4.63	0.61	222.99	0.848
77962.50	296.58	262.87	1039.50	3.95	16.00	129.94	4.80	6.22	1.21	165.86	0.631
149962.50	399.95	374.95	1999.50	5.33	16.00	189.94	4.80	7.17	0.90	277.57	0.740
149962.50	399.95	374.95	1999.50	5.33	32.00	189.94	9.60	10.98	1.80	181.35	0.484
307125.00	563.14	545.38	4095.00	7.51	32.00	255.42	9.60	12.19	1.28	335.34	0.615
										0.03125	127.5

Item1 0
 Item2 0
 Item3 65
 Item4 128
 Item5 128
 Item6 0
 Item7 0
 Item8 1040
 Item9 1040
 Item10 2000
 Item11 32

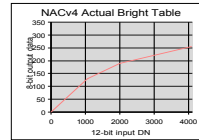
16-bit word Opcode Term select Pad Value

16-bit word	Opcode	Term select	Pad	Value
16896	2	1	0	0
17408	2	2	0	0
17920	2	3	0	0
18497	2	4	0	65
19072	2	5	0	128
28672	7	0	0	0
29168	7	1	0	0
29666	7	2	0	1040
30338	7	3	130	1999
30970	7	4	290	2000
				4095
				255

Actual inputs and outputs

12-bit DN 8-bit data

12-bit DN	8-bit data
0	0
0	0
0	0
65	0
0	0
0	0
0	0
1039	129
1999	189
2000	190
4095	255



Uses 4 slopes and covers 0-4095; cap Nq/Ne for DN<2000
 Nominal; e⁻ < 150000 (bright highlands at 5 degrees incidence) has Nq <= 1.35 * Ne (quantiz <= 4.5 * noise)
 e signal noise e SNR 12-bit DN Noise eq C(DN14) DN8 Quantiz RSS N No/Ne / SNR SNR% Slope Intercept

e signal	noise e	SNR	12-bit DN	Noise eq C(DN14)	DN8	Quantiz	RSS N	No/Ne / SNR	SNR%	Slope	Intercept
0.00	100.00	0.00	8.00	1.33	4.00	2.00	1.20	1.79	0.90	0.00	
600.00	102.96	5.83	8.00	1.37	4.00	2.00	1.20	1.82	0.87	0.00	0.000
600.00	102.96	5.83	8.00	1.37	4.00	2.00	1.20	1.82	0.87	0.00	0.000
8362.50	135.51	61.71	111.50	1.81	4.00	27.88	1.20	2.17	0.66	47.72	0.773
8362.50	135.51	61.71	111.50	1.81	8.00	27.88	2.40	3.00	1.33	34.45	0.558
61162.50	266.76	229.28	815.50	3.56	8.00	115.88	2.40	4.29	0.67	188.19	0.821
61162.50	266.76	229.28	815.50	3.56	16.00	115.88	4.80	5.97	1.35	135.16	0.590
149962.50	399.95	374.95	1999.50	5.33	16.00	189.88	4.80	7.17	0.90	277.57	0.740
149962.50	399.95	374.95	1999.50	5.33	32.00	189.88	9.60	10.98	1.80	181.35	0.484
307125.00	563.14	545.38	4095.00	7.51	32.00	255.36	9.60	12.19	1.28	335.34	0.615
										0.03125	127.4

Item1 0
 Item2 0
 Item3 14
 Item4 65
 Item5 128
 Item6 128
 Item7 1
 Item8 0
 Item9 816
 Item10 2000
 Item11 32

16-bit word Opcode Term select Pad Value

16-bit word	Opcode	Term select	Pad	Value
16896	2	1	0	0
17408	2	2	0	0
17924	2	3	0	14
18497	2	4	0	65
19072	2	5	0	128
28672	7	0	0	0
29164	7	1	0	0
29710	7	2	111	111
30310	7	3	102	1999
30970	7	4	290	2000
				4095
				255

Actual inputs and outputs

12-bit DN 8-bit data

12-bit DN	8-bit data
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